

SAVE \$12,000 IN HOME UPGRADES! P.54

Popular Mechanics

PopularMechanics.com February 2012

FINDING
LIFE ON
MARS

NASA's Risky
New Mission

Science Technology Automotive Home Adventure

GAME

OVER?

12 WAYS THE WORLD
COULD END
IN 2012 *

JUST IN CASE WE'RE
STILL AROUND ...

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Whiskey Making P. 58

Assemble Your
First Robot
For \$100 P. 70

*
NO, NOT
THAT MAYAN
THING.
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Feb.



Classic look, high-tech: New York Distilling Co.'s copper and stainless-steel still.

58 Whiskey Rebellion Blending old techniques and new tech, resolute DIYers are creating high-quality, handmade spirits. PM explores the craft and culture of microdistilling. BY WILLIAM GURSTELLE

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46 That's All Folks . . .

Doomsday alarmists believe that 2012 will be our final year. Not likely. But not impossible either. POPULAR MECHANICS examines 12 ways the world really could end. BY JEFF WISE

54 DIY and Save

Grind away a stump, replace a countertop, lay a stone path: Pros charge big bucks for jobs like these. PM tells you how to save a bundle by doing 10 key home projects yourself. BY BRETT MARTIN

64 64° 46'S, 64° 03'W

Remote and beautiful, Antarctica's Palmer Station is a tiny outpost with a huge mission: document rapid climate change. PM goes on location. BY JENNIFER BOGO

On
the
cover

SOME SAY THE MAYAN calendar pegs 2012 as earth's final year. We disagree. But there are credible apocalyptic theories, based on asteroid impact, nuclear winter, or other cataclysm. Photo illustration by Robert Trachtenberg with Zoic Studios.

PHOTOGRAPH BY CAMERON KRONE

Tech Watch

11 Mars, Here We Come—Again NASA's latest Mars rover, Curiosity, seeks to solve the mystery of life on the Red Planet. But can the 1982-pound rig land intact? **Plus:** A smart lamp post, home-invasion protection—and more.

Upgrade

21 Foot Soldiers New tech, materials, and design make today's best work boots tough and comfortable. **Plus:** Modern takes on kitchen essentials, top gadgets from the Consumer Electronics Show, an indestructible sledge.

New Cars

29 Driver's Delight The 2013 Subaru BRZ is nimble, rear-wheel drive, and affordable. Finally, a successor to the iconic Corolla GT-S. **Plus:** Audi takes a page from its rallying history with the 2012 TT RS; why small cars don't take smaller fuel sips on the highway.



The new-fangled composite toe in the Thorogood Wedge wards off a classic accident—the errant sledgehammer strike.

Work boots today use a composite substitute for steel toes. Fortunately, the boots look the same: They're all tough, no-nonsense industrial icons.
—Supreme Work Boots, page 22

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38 I'll Try Anything: Arctic Engineering PM senior correspondent Jeff Wise heads to the Arctic to learn the art and science of igloo building. Plus, how to build one yourself!

42 Cockpit of the Future New aircraft instruments make flying safer and quicker for business-jet pilots. But why are commercial airlines reluctant to adopt the same tech?

44 My Next McLaren McLaren's second-ever road car, the MP4-12C, is a performance monster with looks to match. Jay Leno can't wait for his to arrive this winter.

On the cover

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PopMech diy



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89 Your Car's Nervous System Modern automotive electronics are complex and mysterious. PM tells you how they work, plain and simple. **92 Car Clinic** Feeling paranoid behind the wheel? You should be. How your car tracks your driving—and shares the info. **Plus:** Low-profile tires look cool, but are they all that?

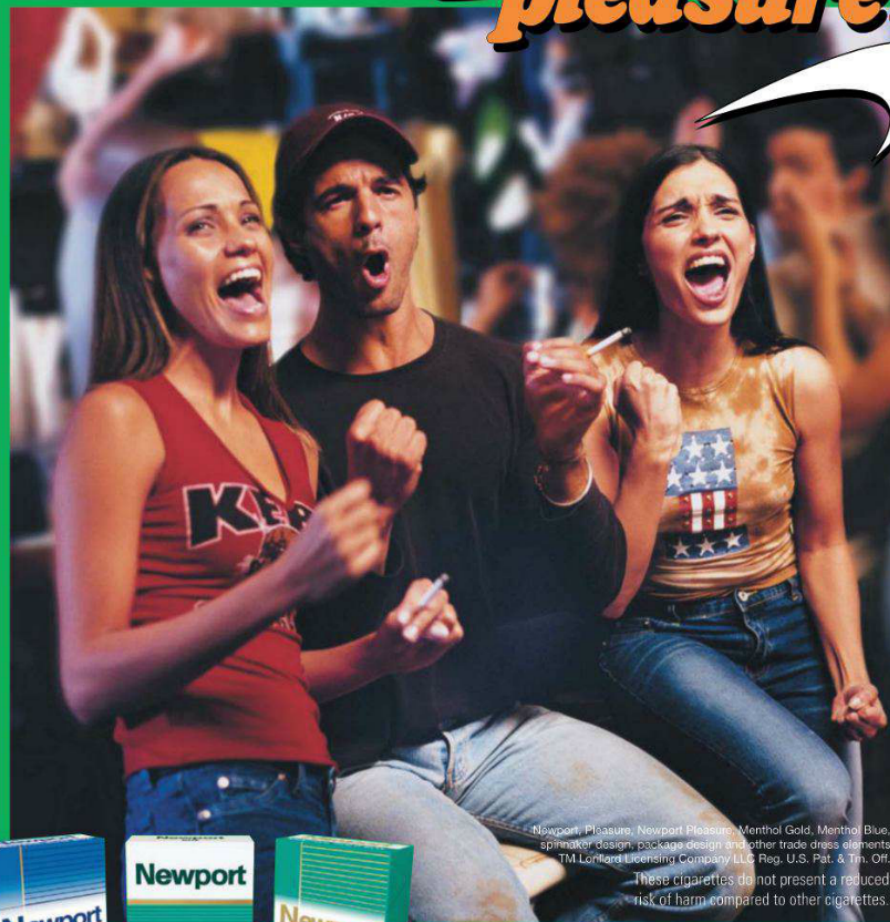
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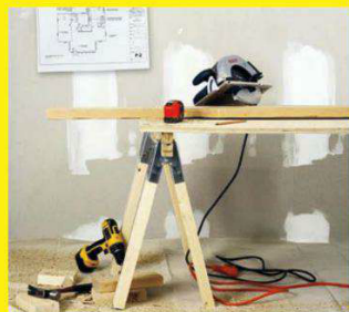
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10 TIPS FOR HIRING A CONTRACTOR Sometimes it makes sense to hire a pro rather than take on a job yourself. But choosing the wrong contractor can lead to delays, subpar work, cost overruns, and even legal problems. Follow these suggestions to avoid getting burned. popularmechanics.com/contractortips



END-OF-THE-EARTH ROADS These routes lead across frozen wastelands, around treacherously narrow mountain paths, and to the very tips of continents. They're the 10 most extreme and isolated roads on the planet. popularmechanics.com/extremeroads

THE PROBLEM OF PATENT TROLLS Nonpracticing entities, or "patent trolls," don't manufacture anything. Instead, they use the patents they own to sue other companies. PM investigates how much money these disputes have cost tech companies over the past two decades. popularmechanics.com/patenttrolls

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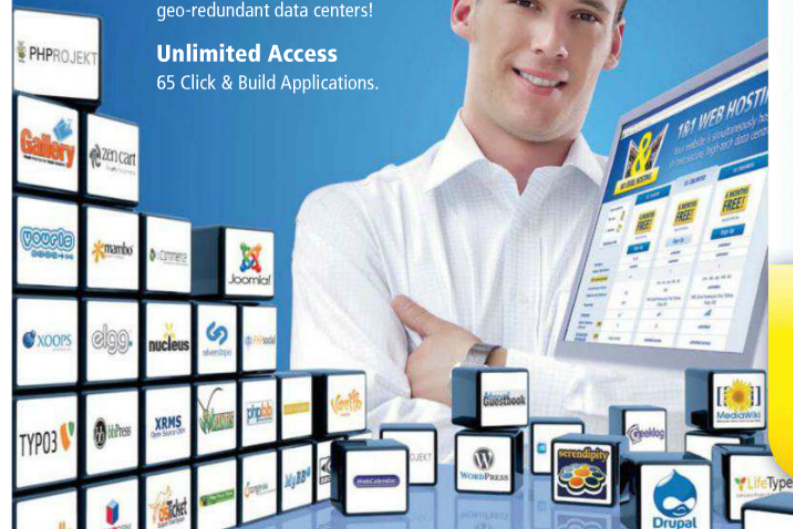
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More Ways to Save

In "We're Throwing Away Energy . . ." (December), you take an in-depth look at energy recovery, but it's worth noting that there's also a lot we could do to redirect energy to reduce waste. The traffic light system could be redesigned to minimize the need for vehicles to repeatedly brake, stop, and accelerate. If intersections were set up as monitored nodes on a grid, and each node shared information with others directly connected to it, real-time data could be used to time the lights for improved traffic flow and—in theory, at least—reduced fuel consumption.

JOHN ERICKSON ORLANDO, FL

Artificial Personality

Your December Tech Watch piece about Robonaut 2, or R2, going into space ("Go Up, Young Bot") was great. The robot seems prototypically human, and by being able to recognize obstacles floating by, a lot less machine-like. I wonder: Has Robonaut begun asking when it's going to get legs?

TAYLOR HEGG NEW ERA, MI

A Jeep Classic

In regard to your review of the 2012 Jeep Wrangler (New Cars, December), with all due respect, you've missed the point entirely. Jeep Wrangler is an enduring brand because its customers know exactly what they're getting when they buy one. Nobody wants a Wrangler to ride, or sound, more like a luxury sport utility vehicle. People who want luxury SUVs buy them! Old-style Wranglers are what they do, and do what they are: sturdy, no-nonsense utility vehicles in the original sense of the term.

PAMELA "SPIKE" CHENEY ANGLE SAN DIEGO

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do you
think?

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EDITOR'S NOTE: We were deeply saddened to learn that Mark Stull, a 59-year-old ultralight-plane builder featured prominently in our October 2011 cover story, "DIY Flight," died in an ultralight-plane crash in November. He was flight-testing an experimental design near his home in Texas. Stull previously had had some harrowing near misses, but he never let the risk keep him out of the air. "Flying an ultralight takes guts," he told PM. "You never know when the engine might die. But I was a whitewater kayaker, and we used to say, 'If we don't almost die, we aren't having fun.'" The cause of the accident is unknown; the National Transportation Safety Board does not investigate ultralight crashes. The PM staff extends condolences to Stull's family and friends.

From our fans
and followers

Hello, PM readers on Facebook and Twitter—and thank you for responding to our stories. Here are some recent comments:

Awesome story about a needed service.

JENNY RUTH MORBER, VIA FACEBOOK
("A Day of Intense Force-on-Force Handgun Training," popularmechanics.com)

PopMech rocks on the iPad!
@MATTHOUSLEY, VIA TWITTER

I have a hard time feeling sorry for companies hit by "patent trolls" since they enjoyed the

benefits of this system and had no problem with the way it worked until it turned around and bit them.

EUGENE W. OLSON, VIA FACEBOOK
("Patent Trolls: How Bad Is the Problem?" popularmechanics.com)

This is a great thought problem because it showcases the limitations of military tactics, and the ultimate preeminence of grand strategy.

MARK BUEHNER, VIA FACEBOOK
("Rome, Sweet Rome: Could a Single Marine Unit Destroy the Roman Empire?" popularmechanics.com)



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► NASA technicians position Curiosity inside the back shell, which contains the sky crane designed to lower the rover onto Mars.

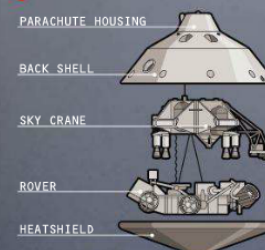
NEWS + TRENDS + BREAKTHROUGHS ◀

Tech Watch



Mars, Here We Come—Again

After a launch on Nov. 26, 2011, that NASA calls "among the most accurate interplanetary injections ever," the Mars Science Laboratory (MSL) is on its way to the Red Planet. If all continues to go well on its 254-day journey, MSL, carrying the Curiosity rover, will reach Mars in August. Curiosity's predecessors, Spirit and Opportunity, found evidence of past water on Mars, and in 2008 the Phoenix Mars Lander discovered perchlorate—a potential food source for microbes. Curiosity will pick up the hunt for signs of habitability by searching for organic material. "If you have sources of food and water and organic material, you could say you have the building blocks of life," says MSL co-investigator Nilton Renno. Mars missions are notoriously complex, so simply reaching the Red Planet will be an important milestone: The Russian Federal Space Agency's Phobos-Grunt spacecraft became stranded in low-earth orbit shortly after its launch in early November. Sixty-five percent of all previous Mars missions—including all 19 launched by Russia or the former Soviet Union—have failed to meet their goals. Here's how NASA built MSL for success. *BY THE EDITORS*





John Schussler
Senior Engineer
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Anatomy of a Rover

The Power Source

Engineers hope Curiosity will rove for at least two years, relying on a unique power source. NASA has outfitted the vehicle with a nuclear-powered battery called a Multi-Mission Radioisotope Thermoelectric Generator (RTG). Drawing energy from the natural decay of plutonium-238 dioxide, an RTG produces almost three times the power of the solar panels that ran Spirit and Opportunity. And, unlike panels, RTGs perform well in dusty and dark conditions.

The SAM

Curiosity carries a 10-instrument package of tools and sensors—including the Sample Analysis at Mars (SAM) suite—to search for signs of life. One instrument features a remote-sensing device capable of targeting pinhead areas on rock formations from up to 23 feet away. ChemCam, as it is known, can then shoot a laser beam at the rock and analyze the vaporized material using light-reading spectrographs. “It has the potential to really study chemical evolution at a different scale than before,” says co-investigator Diana Blaney. “We’ll be able to map [material] composition at a fine scale.” The SAM suite includes a quadrupole mass spectrometer and a gas chromatograph, which, along with the other devices, will work to analyze samples on the surface, inside Martian boulders, and belowground, in the quest to find organic matter.

▶ Curiosity tips the scales at nearly a ton and is almost 10 feet long. Previous twin rovers Spirit and Opportunity were 374 pounds each and just over 5 feet long. All three dwarf the first mobile Mars explorer, Sojourner; it was only 23 pounds and 2 feet long. (Above is a full-scale model of Curiosity at NASA’s Jet Propulsion Laboratory on Oct. 28, 2011.)

PHOTOGRAPH BY SPENCER LOWELL

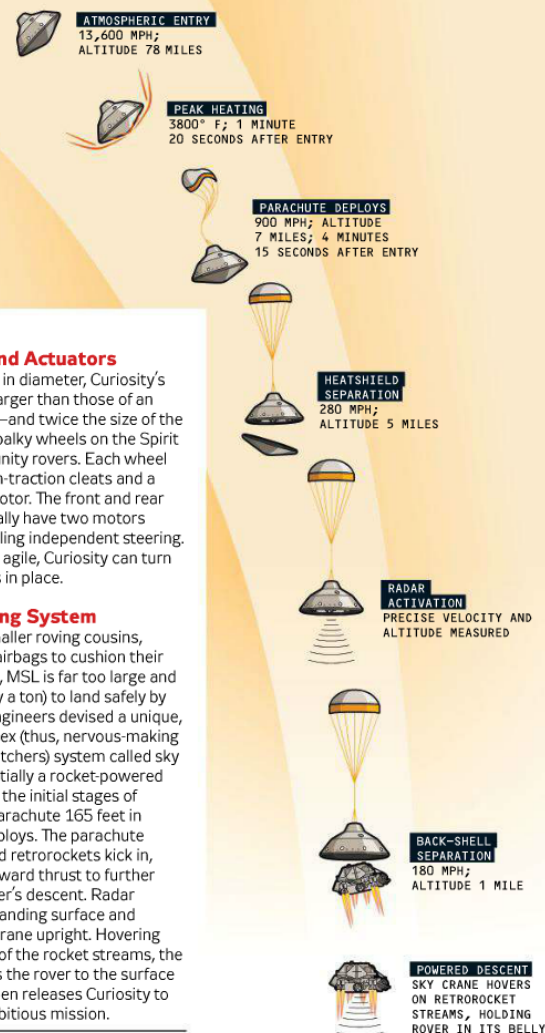
Wheels and Actuators

At 20 inches in diameter, Curiosity’s wheels are larger than those of an average car—and twice the size of the sometimes balky wheels on the Spirit and Opportunity rovers. Each wheel features high-traction cleats and a dedicated motor. The front and rear wheels actually have two motors apiece, enabling independent steering. Impressively agile, Curiosity can turn 360 degrees in place.

The Landing System

Unlike its smaller roving cousins, which used airbags to cushion their touchdowns, MSL is far too large and heavy (nearly a ton) to land safely by bouncing. Engineers devised a unique, highly complex (thus, nervous-making for NASA watchers) system called sky crane, essentially a rocket-powered backpack. In the initial stages of descent, a parachute 165 feet in diameter deploys. The parachute jettisons, and retrorockets kick in, providing upward thrust to further slow the rover’s descent. Radar detects the landing surface and orients the crane upright. Hovering with the aid of the rocket streams, the crane lowers the rover to the surface on cables, then releases Curiosity to begin its ambitious mission.

Andrew Kessler, author of *Martian Summer*, a book about the Phoenix Mars mission, contributed to this article.



FINAL DESCENT

1 Rover Separation

Curiosity decouples from sky crane just 66 feet from surface of Mars.



2 Mobility Enabled

Wheels unfurl as rover, suspended on sky-crane tethers, descends at 1.7 mph.



3 Touchdown

About 6 minutes 43 seconds after atmospheric entry.



4 Flyaway

After tethers unhook from rover, sky crane rockets away, leaving rover on surface to start mission.



DIAGRAMS BY MERCÉ IGLESIAS

World's Smartest Lamp Post

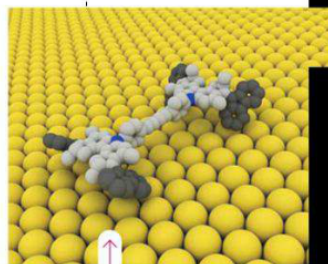
MICHIGAN-BASED ILLUMINATING CONCEPTS IS SELLING WIRED LIGHT POSTS THAT DO MORE THAN BRIGHTEN A STREET CORNER—THEY FORM AN INFORMATION NETWORK. BY JOE PAPPALARDO



• QUICK HITS



ANOTHER SUPERPOWER MADE REAL Researchers at MIT's Lincoln Laboratory, in Lexington, Mass., have built a portable radar system that can peer through an 8-inch concrete wall. Like all radar, the device works by aiming radio waves at a target and measuring the signal that bounces back. The wall blocks more than 99 percent of the waves, but enough still leak through to detect any moving object on the other side. The system outputs real-time video at 10.8 frames per second, quick enough to be useful in urban warfare and search-and-rescue operations. Researchers tested the radar from a distance of 20 feet, but say it is still effective from three times that distance. Next up: mounting the 8.5-foot-long assemblage on a vehicle for mobile field testing. —ALEX HUTCHINSON



Four-Wheel Nano Drive

Scientists are billing a vehicle the size of a molecule as "the smallest electric car in the world." The nanocar, developed by scientists in the Netherlands and Switzerland, measures roughly 2 x 4 nanometers. It has four electrically powered wheels, each of which rotates when excited by voltage from the sharp tip of an electron microscope hovering directly above it. It moves along a copper surface in only one direction, in close to a straight line. Its biggest weakness: fuel economy—a full tank of electric "fuel" lasts for only about a half-revolution of the wheels. —A.H.

An Old Plane Learns New Tricks

America's newest, nuclear-tipped cruise missiles will be carried by an airplane already more than 50 years old, if the Air Force's strategy proceeds as planned. The Air Force has been eager to build a long-range bomber to carry nukes, preferably one that can evade radar while closing in on targets. But that program is languishing—officials have not even decided if the new planes will be piloted, robotic, or optionally manned—and, in the meantime, the B-52 Stratofortress will fill the gap. The tactic: Have the B-52 fire a new air-launched cruise missile far from the target and let the missile, not the airplane, defeat any advanced air defenses. The B-52s tasked with this mission will fly until at least 2040, representing nearly a century of active duty. The airframes and engines will remain the same, but the birds will be upgraded with new hardware (as well as with the nuclear brawn) to extend their service lives. —JOE PAPPALARDO



1. BRAKES

OUT: Nearly obsolete brakes installed in the 1960s.
IN: Newly designed antiskid brakes—like antilock brakes found in cars, only massive—to aid takeoffs and landings.

Scheduled: 2013

2. WEAPONS BAY

OUT: Unguided bombs stacked in its belly, and smart bombs dangling from external pylons.
IN: Upgrades that allow the B-52 to drop smart munitions from inside its belly. They will be mounted on a rotary launcher, which increases weapons payload by 33 percent.

Scheduled: 2015

3. COCKPIT

OUT: Vintage radios used to pass weapon and flight information to other aircraft and ground forces.
IN: A digital communication "backbone" that will let B-52 crews share data rapidly—for instance, to provide pilots in combat with updates on target coordinates.

Scheduled: 2014

4. RADAR

OUT: Antiquated radar, created in the 1960s and upgraded in the 1980s.
IN: Modern radar, likely adapted from systems currently used by military aircraft.

Scheduled: 2013



MAGNETIC TONGUES They take their tomato sauce very seriously in Italy. Scientists there have developed the first mechanical taster to rely on nuclear magnetic resonance—the same technology used in MRI scanners—to analyze canned tomatoes. The device applies pulses of electromagnetic radiation and measures the tiny signals emitted by the various amino acids and other components of the *pomodora*. The device (co-created with researchers from Denmark) measures sweetness, sourness, saltiness, tomato taste, metallic taste, and density in each sample.



THE NEW BLACK Common black paint absorbs, at most, 90 percent of the light that hits it. So a new coating developed by NASA engineers that absorbs more than 99 percent of the incoming spectrum—not just visible light, but also ultraviolet, infrared, and far-infrared—qualifies as "superblack." The coating is basically a shag carpet of carbon nanotubes. Incoming light is trapped in the tiny gaps between the tubes instead of being reflected. Ultrasensitive space telescopes could use these materials to prevent photons from straying into their detectors.



2 PLANT THORNY BUSHES AROUND WINDOWS.

Not only do these shrubs serve as an aesthetically pleasing deterrent, they also can collect DNA from blood and skin. And torn clothes can leave evidence that does not require an FBI lab to analyze.



3 HANG A BELL ON THE DOOR.

Anyone entering will trigger this simple, unobtrusive alarm.

4 DESIGNATE A SAFE ROOM . . .

and make sure to tell your family or roommates so they know where to go in a crisis. The room should have a landline phone, a flashlight, and, if you own one, a firearm. Mount doors on hinges that swing out; they are harder to breach than those that swing in.



5 STORE YOUR GUN SOMEWHERE ACCESSIBLE, AND WITH A FLASHLIGHT.

A gun safe should have rubber buttons because, according to Gun For Hire instructor and police detective John McAloon, "biometric safes can fail if your fingers are sweaty or covered in blood." Instead of a weapon-mounted flashlight, keep a spare handheld light to avoid pointing a gun at neighbors, family members, or cops.

6 KNOW THE LOCAL LAWS. Use-of-force laws differ by state: In New Jersey, you can shoot only if there is no escape route or if someone else is threatened; in Ohio, it's legal to shoot trespassers just for being there. "Every bullet you fire comes with a lawyer attached," says Joe Sente, a police officer and Gun For Hire instructor. Check your state attorney general's website for details.

7 KEEP A SPARE FRONT-DOOR KEY ON A CHAIN WITH A GLOW-STICK.

If you're stuck on an upper floor when the police arrive, how will you let them in? Crack the glowstick and toss it out a window so officers can gain quick access to your front door.

PERSONAL SAFETY

Home Sweet Fortress

THE KEY TO A SECURE HOUSE IS A LAYERED DEFENSE, FROM STRATEGIC SHRUB PLANTING TO TACTICAL DOOR HINGES.

BY CHAD HUNT & JOE PAPPALARDO

Statistically rare but devastating, home invasions are the kind of low-probability, high-consequence nightmare that is difficult to guard against without seeming and feeling like a hopelessly paranoid person. But that doesn't mean you shouldn't be prepared. New Jersey-based Gun For Hire, which provides tactical training for law enforcement and civilians, teaches that the best way to stop a home invasion is one step at a time.



1 IF YOU OWN A GUN FOR SELF-DEFENSE, PREPARE.

Gun ownership comes with grave responsibilities and may not be for everyone. Pull a gun only if you are trained to use it. Practice shooting with both eyes open—depth perception and peripheral vision are needed in an actual gunfight.

SAFETY SENSORS



Radiation Tricorder

→ As workers at the wrecked Fukushima reactor learned, there is no equipment available that can accurately measure all three types of radiation (alpha, beta, and gamma) at the same time. Having separate detectors for each is not only cumbersome and expensive, it also forces workers to spend more time in the contaminated area, increasing exposure. Researchers in Japan have developed a hybrid detector with three different "scintillator" layers: The first, made of plastic, emits a pulse of light when struck by alpha particles; the second does the same for beta particles, while the third detects gamma rays. The instrument examines the signals separately and calculates the dose of each.

—ALEX HUTCHINSON

ALPHA

PARTICLE EFFECTS

Most cannot penetrate human skin, but are harmful if swallowed or inhaled.

DETECTED BY

Plastic

BETA

PARTICLE EFFECTS

Can penetrate to where human skin cells are produced.

DETECTED BY

Gadolinium silicon oxide

GAMMA

PARTICLE EFFECTS

Able to burrow inches into human tissue.

DETECTED BY

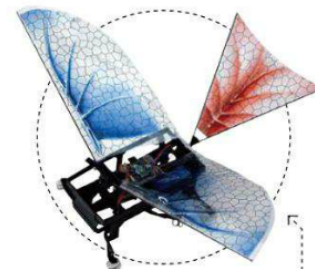
Gadolinium silicon oxide

TECH WATCH

PREHISTORIC MYSTERIES

Up in the Air

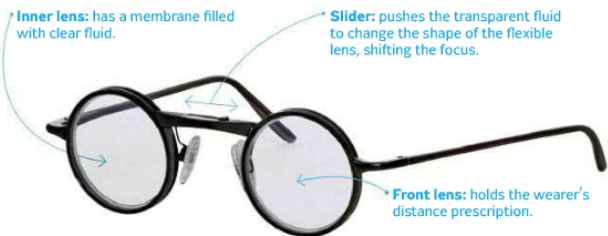
No matter how hard it flaps its wings, the six-legged DASH+Wings robot modded by engineers at the University of California, Berkeley, can't fly—and that's the point. (For the acronym obsessed: DASH stands for dynamic autonomous sprawled hexapod.) Archaeologists have long debated whether the first birds evolved from tree-dwelling gliders or from animals that flapped their primitive wings to run faster. The DASH bot covers ground 90 percent faster when it has flapping wings, far short of the four-fold boost that a running *Archaeopteryx* dinosaur would have needed to get airborne. In wind-tunnel glide tests, DASH+Wings did improve lift, but that doesn't change the verdict: The first true fliers probably evolved from tree-based gliders. —A.H.



BODY LENGTH: 4 IN. WINGSPAN: 12 IN. WEIGHT: 25 GRAMS

ORBITAL OPTICS

These Are Your Eyes on Space



→ The view from orbit is amazing. But your vision in space—well, not so much.

Researchers have known that long-duration space travel causes bone loss and weakened muscles. But new studies show that it also creates vision problems.

Medical experts suspect that fluid shifting to the head causes a rise in pressure around the optic

nerve at the back of the eye. This pressure pushes the retina forward and causes farsightedness.

For the past 20 years, NASA has been sending astronauts up with one or more pairs of "space-anticipation glasses," which have amped-up power, to wear as their sight declined. These kinds of glasses are also available

for Earth dwellers whose eyes have lost the ability to refocus from far to near. Superfocus specs have a slider that wearers use to adjust the prescription. Every shuttle mission launched in 2011 had Superfocus glasses on board, and the glasses are now kept in stock on the International Space Station. —STEPHANIE WARREN

SHIFT the way you move



11:32 AM
MARKETER

near-vertical
sidewalls offer ample
advertising space

12:01 PM
HEADQUARTERS

high roof available with
up to 320+ cu ft. for cargo
and 6'3" of headroom

2:45 PM
CORNER OFFICE

optional locking center
console includes file
cabinet and laptop storage
with 120V power

7:15 AM
EXTRA HAND

magnetically secured
243-degree opening rear
doors with storage pocket

6:12 PM
STORAGE FACILITY

choice of either custom
shelving or exterior graphics
at no additional charge

4:45 PM
POWER PLANT
powerful 5.6L V8 and
4.0L V6 engine options

INNOVATION THAT WORKS

The All-New Nissan NV Lineup



Being your own assistant is never easy. It's especially tough when you're acting as a marketing agency and storage supervisor too. Luckily, the Nissan NV is well-equipped with reinforced mounting points for shelving that eliminate the need for drilling into sheet metal, ample exterior space for advertising, and near vertical sidewalls that maximize cargo space and minimize the number of trips you need to make. So you can concentrate on the task at hand.

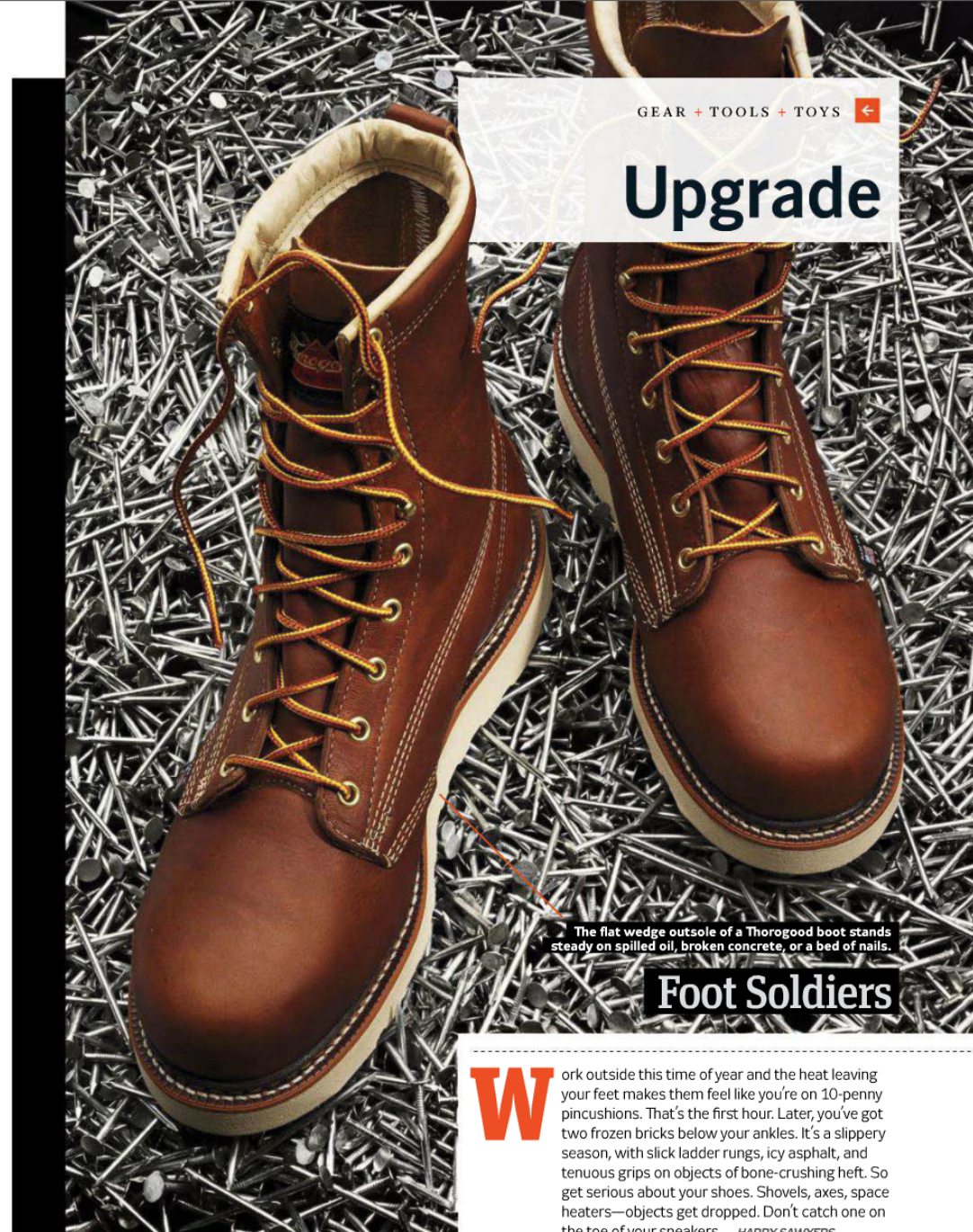
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GEAR + TOOLS + TOYS

Upgrade



The flat wedge outsole of a Thorogood boot stands steady on spilled oil, broken concrete, or a bed of nails.

Foot Soldiers

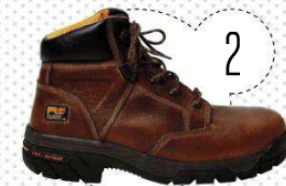
Work outside this time of year and the heat leaving your feet makes them feel like you're on 10-penny pincushions. That's the first hour. Later, you've got two frozen bricks below your ankles. It's a slippery season, with slick ladder rungs, icy asphalt, and tenuous grips on objects of bone-crushing heft. So get serious about your shoes. Shovels, axes, space heaters—objects get dropped. Don't catch one on the toe of your sneakers. —HARRY SAWYERS

PHOTOGRAPH BY PLAMEN PETKOV

POPULARMECHANICS.COM | FEBRUARY 2012 21



1



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6

Kick a Job in the Teeth With Supreme Work Boots

Steel-toed boots help lift drywall panels into position and protect feet from falling compressors. But those steel inserts have a bad tendency to conduct heat, cold, and even current. A new generation of boots uses a nonmetallic composite substitute. No, that doesn't sound as cool as saying "steel-toed." But the boots look the same: They're tough, no-nonsense industrial icons.

1. FOR THE ARBORIST

→ The Oregon-made **Danner Super Rain Forest** (\$355) has a Gore-Tex lining, triple-stitched seams, and a nonmetallic safety toe clad in two layers of full-grain leather.

2. FOR THE WELDER

→ The **Timberland Helix** (\$160) sole is like an antifatigue mat, a key to working long hours on hard floors. A sole notch hooks a ladder rung, the heel firmly grips a foot, and an antimicrobial lining keeps feet fresh—or at least less funky.

3. FOR THE CARPENTER

→ Most steel-toe caps cover the front fifth of a foot. But the asymmetrical safety toe on the **Keen Tacoma** (\$150) is full-size over the big toe and slimmer over the smaller ones, shedding weight and maximizing mobility.

4. FOR THE MECHANIC

→ The classic **Thorogood American Heritage Wedge** (\$167) has tobacco-hued tanned leather, a cotton lining, and a heel-free rubber outsole, aka a wedge. It maximizes traction on slick or uneven surfaces with the help of a shock-absorbing footbed.

5. FOR THE MACHINIST

→ Metatarsal guards, which shield the top of the foot from heavy drops in a shop, are usually stiff, strap-on steel plates. A **Red Wing 4421** (\$180) integrates a flexible, invisible, impact-resistant membrane into the boot's tongue.

6. FOR THE MASON

→ Welt technology on the **Wolverine Corsair** (\$163) lets the shoe flex with each footfall while contouring to support arches. Pads along the sole absorb impact. An abrasion-resistant layer wraps the toe to stop the scuffing that results from working while kneeling.



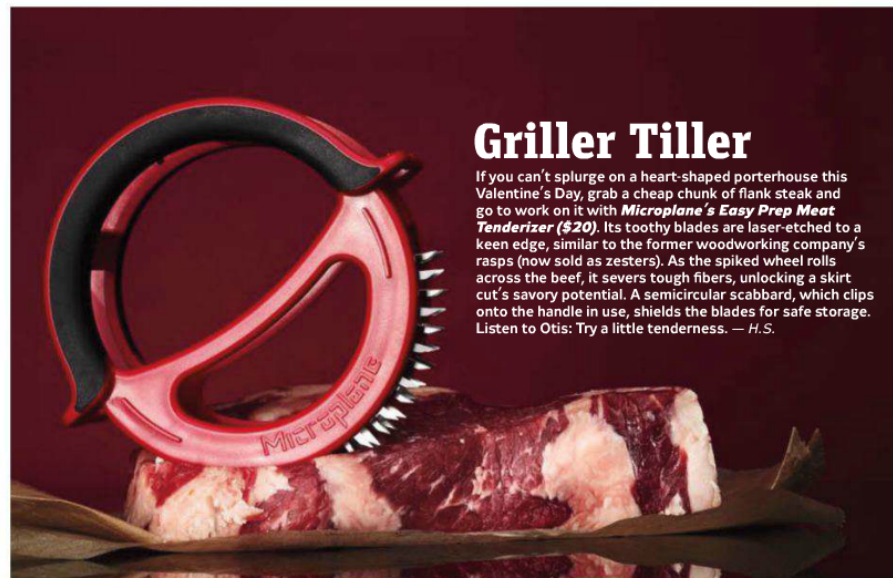
A certified nonmetallic toe protects feet without steel's drawbacks. "This is 100 percent where the industry is headed," says Danner boot builder Hans Albing.

"On MythBusters, we dropped progressively heavier weights on steel-toed boots to see if they'd curl over and act like knives to cut your toes off. They do not. But we found that the steel toes can, in a pinch, make decent hammers."

— CO-HOST JAMIE HYNEMAN



PHOTOGRAPHS BY PHILIP FRIEDMAN (BOOTS), PLAMEN PETKOV (CUTAWAY)



Griller Tiller

If you can't splurge on a heart-shaped porterhouse this Valentine's Day, grab a cheap chunk of flank steak and go to work on it with **Microplane's Easy Prep Meat Tenderizer** (\$20). Its toothy blades are laser-etched to a keen edge, similar to the former woodworking company's rasps (now sold as zesters). As the spiked wheel rolls across the beef, it severs tough fibers, unlocking a skirt cut's savory potential. A semicircular scabbard, which clips onto the handle in use, shields the blades for safe storage. Listen to Otis: Try a little tenderness. — H.S.



Pack Your Knives

Sharpened by robots on a whetstone in Solingen, Germany, the forged **Wusthof Classic 8-Inch Cook's Knife** (\$120) (left) is the result of computer-controlled honing that eliminates the geometric irregularities in a hand-sharpened knife. At one-sixth the cost, the 7-inch **Kuhn Rikon Nonstick Chef's Knife** (\$20) (right) has a coated steel blade that effortlessly releases anything it cuts. The dishwasher-safe Kuhn includes a protective sheath. Calling all cooks: These are both superior slicers.

BEST VS BUDGET

A high-carbon-steel tang extends through the handle, making the tool ideal for quartering poultry, butchering hogs, and sharpening annually for life.

The anticling coating lets the versatile utility tool chop veggies and cheese with ease. With a sheath, it can travel. At this price, you can afford to lose it.



MAMA'S IRON SKILLET

→ Forged in South Pittsburgh, Tenn., the cast-iron **Lodge Logic Deep Skillet** (\$52) has 3-inch sides and a 10½-inch diameter. The durable frying pan should last 100 years, and its preseasoned iron performs beautifully even new. Go with a glass lid to keep an eye on what's simmering inside.

HYBRID CUTTING BOARD

→ Like a culinary nesting doll, **J.K. Adams's Sutton Cut and Serve** (\$84) fits a maple cutting board and a serving tray inside a 19 x 12 x 1-inch footprint. Carry the tray by the undercut handles, leaving the teak-oil-finished cutting board behind for slicing charcuterie.

INDUCTION HOT PLATE

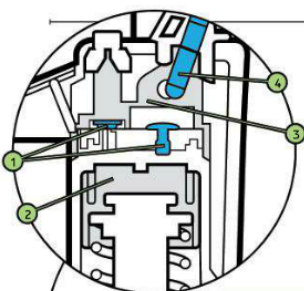
→ To take induction cooking for a test drive without giving up a gas range, try **Kenmore Elite's Single-Burner Portable Induction Cooktop** (\$200), a 1500-watt burner that runs off a basic 120-volt outlet. Enjoy steady, powerful heat in any pan capable of attracting a magnet.

PHOTOGRAPH BY PLAMEN PETKOV



Sick Slope Specs

Ski and snowboard goggles often feature interchangeable lenses, and the **Oakley Airbrake Snow Goggles (\$220)** reduce the hassle of making a switch halfway down a frozen mountain. An integrated lever, operable by a gloved hand, pops out a lens as conditions change, then quickly allows another to be mounted inside the fleece-lined frame. The flexible chassis minimizes nasal pinching, yet holds the lens taut to prevent distortions.



1 WATER AND AIR ENTER THE DEVICE

A pull of the trigger opens an inlet to let outside air into a chamber in the handle. A separate reservoir opens to allow water to enter a mixing chamber.

2 A PISTON ADDS AIR PRESSURE

A spring in the air chamber compresses and releases, forcing a piston seal to the top of the chamber. An umbrella valve opens to mix pressurized air with water.

PLAQUE BLASTER

Like a pressure washer for your mouth, the **Philips AirFloss (\$90)** knocks plaque off teeth in what company project manager Wolter Benning calls a "disruption event." "The collision is like a series of train cars," Benning says. "When a high-speed droplet impacts wet plaque film, it creates a shock wave. Pressure builds up to mechanically disrupt the film." Once the plaque is loose, water flushes it out. Here's a look at what goes on in a single 500-millisecond shot.

3 THE ELEMENTS CONVERGE

In the mixing chamber, which Philips calls the dropletizer, pressurized air and water are forced up into the spray arm.

4 FIRE IN THE HOLE!

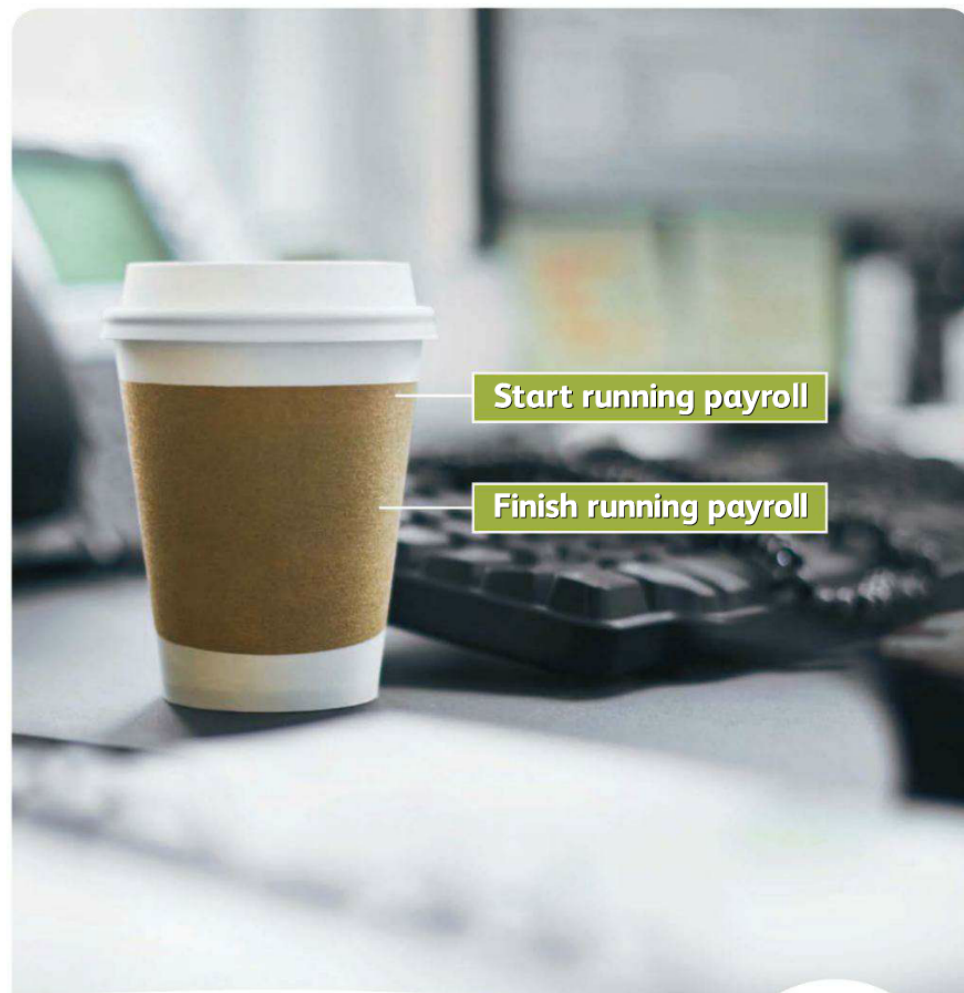
The rush of air breaks the water into tiny particles and carries it out of the spray arm. The arm tapers to 1.2 mm at its tip, causing the mix to accelerate as it exits. Final speed: more than 20 meters per second.

BEAT THE TAR OUT OF IT

Product designer Tim Onello offers \$1000 to anyone capable of breaking the handle on his **Bad Ass Sledge Hammer (\$84)**. Onello says the deal is only for "normal usage" of the 13.2-pound tool. "That's a person swinging it with two hands, no matter what he's hitting," he says. (Running it over with a bulldozer is abnormal.) Word of caution: In tests, the BASH survived 25,000 strikes.

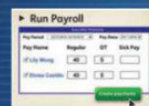


DIAGRAM BY VIC KULHIN



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*Based on the Hoover's Report as of October 13, 2011.

digital Preview 2012

January's Consumer Electronics Show (CES) is the most important event on the tech calendar—it's where hundreds of companies, big and small, unveil their hottest gadgets for the coming year. Here are the 11 products you should know about for 2012.



SAMSUNG WI-FI CAMERA

→ This hockey-puck-size surveillance camera doubles as a baby monitor—or is it the other way around? After syncing with a Wi-Fi network, it becomes instantly accessible from across your house or, with a smartphone app, from across the world. Two-way voice communication calms the nerves of jumpy parents. All other paranoid types will enjoy that it works as a motion sensor and can upload video evidence to a private YouTube account.



TOSHIBA REGZA 55X3

→ What comes after high definition? Really high definition? Highest definition? Well, technically, it's just called 4K. Toshiba's 55-inch Regza 55X3 (currently on the market in Japan) displays 3840 x 2160 pixels. That's four times the resolution of a 1080p TV and an even greater level of clarity than a movie theater's digital projector provides. Since 4K content is scarce (for now), the Regza has another trick behind that big panel: It shows autostereoscopic 3D, with no glasses required. (But that's plain old HD.)



EXOPC EXODESK TABLE

→ Released in 2008, Microsoft's Surface touch table was the first of its kind—a beautiful, multitouch glass wonder, ripped straight from the realm of sci-fi. It also cost as much as an inexpensive car. The ExoDesk, from the Canadian tablet firm ExoPC, projects a custom-designed touch interface across a desk for just \$1300, or about one-tenth of the Surface's price.

WINDOWS 8 TABLETS

→ Tablets inundated last year's CES, flooding the show floor with about 100 unique products. (And yet, one year later, how many can you actually name?) Google's Android has been the operating system of choice for non-Apple tablets so far, but now it's Microsoft's turn. Samsung teased a Windows 8 tablet last year. CES should finally give us some real hardware to look at.



INTEL ULTRABOOKS

→ Ultrabooks are super light, unbelievably thin, and—judging by the coming onslaught from the world's biggest PC manufacturers—the inevitable future of laptops. CES organizers expect the introduction of 30 to 50 Ultrabooks at the show this year. (For context, research firm NPD counted just 260 unique PC laptops on store shelves in 2011.) This means that everyone—HP, Asus, Lenovo, and even Dell—will march down the path blazed by the MacBook Air.



NVIDIA TEGRA 3 CHIPSET

→ If you've used any non-iPad tablet, there's a pretty good chance it was based on the Tegra 2, a powerful system-on-a-chip from graphics-card company Nvidia. The Tegra 3 promises lower energy consumption, faster processing, and console-quality game graphics.

INTEL IVY BRIDGE PROCESSORS

→ Intel's first laptop chips to use the company's brand-spankin'-new 22-nanometer manufacturing process, Ivy Bridge processors slash power use while offering a slight increase in processing capability, plus a huge boost in graphics performance. But forget about clock speed and graphics benchmarks—those are expected. It's the promise of all-day laptop battery life that's got us seriously excited about Ivy Bridge.

QUALCOMM GOBI 4000 WIRELESS CHIP

→ 4G wireless data is astoundingly fast but wreaks havoc on battery life. Qualcomm's Gobi 4000 is a 4G wireless chip for smartphones and tablets that connects to broadband-speed 4G networks without a significant power penalty. Most of the biggest smartphone manufacturers, including Apple, already use Qualcomm wireless chips in their products. Apple doesn't make a 4G iPhone—yet. We'll find out if Apple goes there with a Gobi.

NOKIA KINETIC CONCEPT

→ One of a few flexible devices emerging from research labs this year, Nokia's Kinetic smartphone concept isn't flexible just for the heck of it: Bending the handset actually triggers actions onscreen. Twist one way to switch apps and the other to switch back, or bend the screen toward or away from your face to zoom in on or out of an image.

GRACENOTE ACR → Gracenote is one of those vaguely familiar company names. That's because Gracenote's music-recognition technology has been dutifully identifying CD track names in apps like iTunes and Windows Media Player for years. Gracenote's new automatic content-recognition (ACR) software for tablets, phones, and TVs identifies shows and movies based on audio signatures, then serves up related information—Twitter feeds, IMDb entries, and, um, advertising—without any user input.



LYTRO CAMERA → Lytro's light-field camera captures the directionality of light, along with its intensity and color. The photos it records, if you can really call them photos, can then be refocused after they've been shot. Lytro's early demos felt like magic—its images seemed eerily alive. Now the company has finally released a camera for sale. This strikingly minimalist rectangular prism of a gadget will retail for \$400.





U.S. Department
of Veterans Affairs

*"The Navy called it a
hard, hard landing.
We called it a crash."*

John

US Navy, US Army National Guard,
US Navy Reserve
1980-1993, 2005-2008

John served his country in the Army National Guard and the Navy.

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+ base price \$25,000 (est)

ENGINE
2.0-liter flat four;
200 hp, 150 lb-ft

TRANSMISSION
six-speed manual

0-TO-60
7.0 seconds (est)

BRAKES
four-wheel discs



DRIVER'S DELIGHT

To build its first-ever rear-wheel-drive sports car, Subaru started by cutting the fat, keeping the weight to 2700 pounds. That's nearly as light as a base Mini Cooper, but the BRZ has significantly more horsepower (200 versus 121). The results are thrilling: At over 100 mph the BRZ is poised and stable. As the car drifted sideways at 45 mph through Subaru's Tochigi, Japan, tight autocross proving grounds, the

steering was precise and deft. Compared with Subaru's boisterous WRX STI the BRZ is purer and more refined, with a slick-shifting six-speed manual and an exceedingly balanced and very forgiving chassis. One reason the car handles so well: Its 2.0-liter boxer motor sits lower in the chassis than the engine of a Porsche Cayman, a good comparison because the BRZ is about the same size. Subaru, however,

managed to squeeze in a pair of tiny back seats, to make this driver's car a little more practical. If 200 horses sounds a hundred or so shy of the competition, remember that the BRZ is 1000 pounds lighter than a Camaro. The BRZ may not gun down a V-8 muscle car in a stoplight war, but it's not meant to; it's meant to straighten curves, and Subaru comes up pure aces on that score.

— MICHAEL FRANK

New Cars TEST DRIVES

O FAMILY MATTERS

The fourth-generation 2012 Honda CR-V (about \$21,000) got bigger inside, with more cargo room as well as standard, one-touch mechanically folding second-row seats. It looks a bit more refined than previous models too. But engineering—Honda's bread and butter—really wins the day, with a new AWD system that eliminates torque steer by sending more muscle to the rear tires, and a stability-control system notable for its lack of intrusiveness. Maybe the most pleasant update is to the suspension, which features longer travel. That may seem like shorthand

for "soft handling," but the CR-V is actually quite responsive and borderline sporty—and far less busy than the outgoing model. Standard features such as a rear-facing camera and the lowest hatch load floor on the market are likely to be big hits (at 23.6 inches high, it's 1 inch lower than in the 2011 model). In all, this is an exceedingly polished vehicle, especially in a segment where cheap plastics, booming interiors, or harsh rides are still too-common prices to pay for wanting a tall car. This stalwart trucklet is perfectly enjoyable as a daily driver.

—MICHAEL FRANK



2012
Buick Verano

2012
Honda CR-V

27.9/
100,000

Livonia, Mich., has the highest concentration of speed traps (27.9 per 100,000 residents), according to the National Motorists Association (NMA). A speed trap, as defined by the NMA, is a stretch of road with an arbitrarily low speed limit and heavy enforcement.

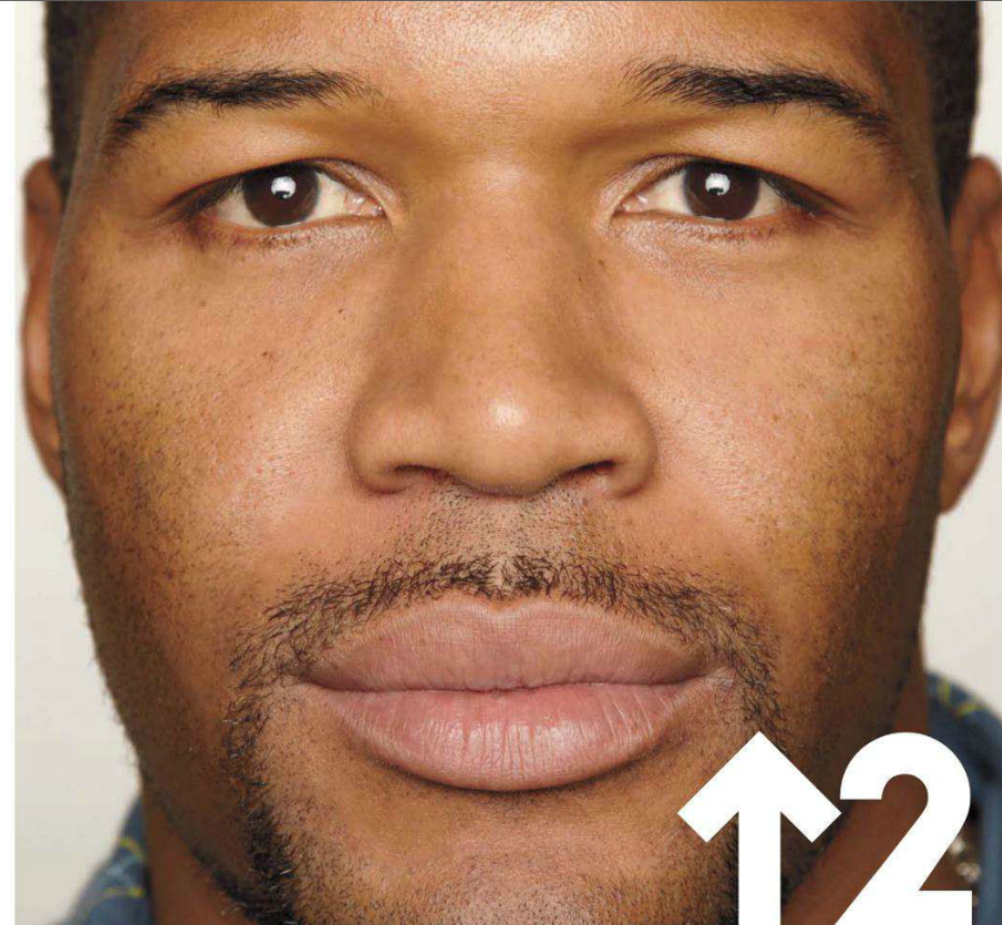
2.5

The amount of teenage-driving instruction in hours offered by Toyota—for free—via the company's Toyota Teen Driver program. By the way, participants do not need to own a Toyota to participate.

COMPACT LUXURY

Buick continues its brand revamp with the new \$23,470 Verano, an upscale version of the compact Chevy Cruze. But where the Cruze comes with 138 hp, the Verano sports 180 hp and 171 lb-ft of torque from a 2.4-liter four-cylinder and a six-speed automatic transmission. A 2.0-liter turbo motor and six-speed manual will arrive later this year. Despite a rainy test drive, the car accelerated briskly with smooth, unintrusive shifts and deftly changed direction. The suspension handled potholes and storm-drain depressions with ease. The Verano is swaddled with sound-absorbing materials—and thicker glass—making the plush cabin even quieter than that of the Cruze. The compact segment, however, is stocked with solid cars—like the Cruze and the Ford Focus—that drive terrific, cost less, and get better mileage than the Verano's 21 city/32 highway. Sure, the Verano is hushed inside and has a few extra bells and whistles—such as a heated steering wheel—but if we were writing the check, we'd wait until next spring, when we'll sample the more compelling turbo version.

—ANDREW DEL-COLLE



↑2

EVERYONE TO BE A HERO

Mike D'Anthony

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New Cars TEST DRIVES



REIMAGINING AN ICON

Over the 911's 49-year life span, every generation has delivered greater performance. But increased fuel economy? Who cared? Yet the new \$80,050 911 will deliver the same 350 hp as before, but with 16 percent better fuel economy (about 30 mpg highway). It's also longer, lower, and wider, but lighter by about 100 pounds. Two seven-speed gearboxes are available: an automated dual-clutch unit and a manual. Toe into the throttle and the flat six sounds deliciously throaty, thanks to ducts that pipe intake sounds directly to the cabin. On our mountain-road drive in Southern California, it was incredibly easy to master the curves. The new electromechanical steering system still delivers accurate information from the front end; the shocks are just more adept at keeping the tires glued to the asphalt. And that helps make it smoother and less fussy to drive very quickly. In short, the 911's rough edges have been buffed clean off. — *B.S.*

○ RALLY SPORT

Audit Trails

Porsche 91:

The heart of the new \$57,725 TR RS is a turbocharged five-cylinder that harks back to the very successful racing Audi Quattros of the 1980s. Today's 2.5-liter version is joined to a sweet-shifting six-speed manual and produces a stomping 360 hp and 343 lb-ft of torque, plus a raspy exhaust tone. Underneath the subtly muscled sheet metal is a lowered suspension, adjustable magnetorheological dampers, and a set of very large disc brakes. The power is tremendous. It hits so hard and so effortlessly, even when the tachometer is at just 2500 rpm. It's a good thing our car had the suede-like Alcantara seat inserts to keep us from sliding around, because the TR RS is easy to drive aggressively. You can floor it midcorner and the all-wheel drive pulls you around. Push the S button on the dash and a valve opens in the exhaust, intensifying the engine's deep moan. In fact, the low-rpm exhaust note is so loud, it vibrates the interior trim. Cool.

— BEN STEWART

AUTO

57

The number of LEDs used in each of the Audi A6's headlights. Each low-beam unit consumes a modest 40 watts, which is more efficient than xenon-plus headlights and just plain embarrasses conventional halogen headlights.

300,000

The number of USB drives Ford plans to send to customers who have its Sync and MyFord Touch infotainment systems. The USB provides updates and patches to address criticisms the system received in a Consumer Reports survey last year.

TECHNICAL KNOCKOUT

In the world of compact cars, 40 highway mpg has become the new benchmark. For the latest 3 (\$15,995), Mazda achieved that figure with the new Skyactiv four-cylinder. This engine, which earned a POPULAR

MECHANICS Automotive Excellence award, utilizes a variety of innovative tweaks—a high 12:1 compression ratio being one—to improve combustion and lower frictional losses. Paired to either a six-speed manual or an automatic, the new engine produces 155 hp. The 3 also offers options such as a blind-spot monitoring system, which used to be available only on more expensive cars. We spent a day in the new 3 dicing through the canyons of Southern California's Angeles National Forest and found that this fuel miser still entertains. The steering clearly relays what's going on at the front tires, and overall the car feels better built than others in its class. The new engine may pack quite a bit of bleeding-edge tech, but it doesn't sound sporty or behave exotically. In fact, it's quite tame. There's enough power to keep the experience behind the wheel lively, but it could use a little more grunt. Still, that's a compromise we're willing to make to hit that magic 40 mpg.

— BEN STEWART



2012
Mazda3

2013
Lexus GS

-40° F The temperature at which a Maxwell Technologies ultracapacitor can easily start a tractor-trailer diesel engine. These lightweight electrical-storage devices augment lead-acid batteries with a powerful zap of energy that brings cold engines to life.

5 The number of remotely operated cars Ford is testing at its Romeo, Mich., Proving Grounds. The simulated track used to test durability is so severe that human drivers can't physically handle the continuous abuse. Robotic pilots, however, can take all-day beatings.

FRESH MUG

The new Lexus GS—about \$48,000—is the first Lexus to wear the brand's fresh spindle grille, which gives the model a curiously pinched beak that may not be pretty but certainly is memorable. It's also the first GS without a V-8 option. All three trim levels—Base, Luxury, and F Sport—are powered by a 3.5-liter 306-hp V-6. Though the wheelbase is unchanged from that of the previous model, interior space and rear legroom have been improved through more efficient packaging. And the seats

are shockingly comfy. Our test car's optional Dynamic Handling four-wheel steering package adapted nicely to varying road surfaces, though we would have preferred stiffer damping and punchier shifts in the most aggressive Sport S+ mode. Those wanting more performance will have to opt for the GS 450h hybrid, which offers 338 hp and smoothly travels with slick urgency. Though the outgoing hybrid was quicker, it can't touch this model's EPA combined fuel-efficiency rating of 31 mpg. — BASEM WASEF



THE SPARK'S WINDSHIELD ANGLE is about 33 degrees, closer to vertical than most larger cars. While that design yields more interior space, it also increases aerodynamic drag and reduces highway fuel economy.

TURBULENCE AT THE BACK OF THE CAR causes a low-pressure zone that pulls the car rearward. More turbulence means greater drag, which the engine has to work harder to overcome.



WHY DON'T PINT-SIZE CARS GET BETTER MPG?

SOMETIME IN THE NEXT 12 MONTHS, Chevy will introduce the Spark, a 12-foot-long car that, along with the Fiat 500, looks like a rolling suitcase compared with the SUVs that populate our highways. Logically, you'd think that the main reason to drive such a small car would be: (a) that it's cheap and (b) that it gets great fuel economy. You'd be right about the first part, but a little off the mark about the latter.

While the Spark's official EPA figures aren't out yet, GM insiders have said that the highway number will be around 38—slightly lower than that of other larger cars in the lineup. Go up one size class to the Chevy Sonic and you can get 40 highway mpg. Another step up yields 42 mpg in the Cruze Eco. This scenario is not unique to Chevy. That Fiat 500 gets 38 mpg on the highway, and the new Scion iQ nets 37. Again, both figures are lower than in significantly larger cars.

Many aspects affect fuel economy. The biggies are engine size and efficiency, vehicle weight, and aerodynamic drag. How large a role each plays depends on how you drive. On the interstate, aero drag is the dominant player, and it turns out that a vehicle's length has a huge effect on drag. And counter-intuitively, short cars have higher drag than longer ones.

"The Spark's short length impacts the drag in two main ways," explains GM's small-car development manager, Dan

Molnar. "First, the grille and windshield are more upright to allow greater passenger space, and second, there's simply not enough length to smoothly guide air around the car."

The drag occurs at both ends: the air hitting the front of the car, and the vacuum created as the turbulent airflow spills off the car's rear. Longer cars may weigh more, but they can better approximate a teardrop shape, resulting in slightly less resistance as they travel, which helps highway mpg. Engineers attempt to reduce drag on shorter cars with various body features, such as smaller wheel openings and sometimes a rear lip spoiler, but there's only so much that can be done. The Spark's drag coefficient is a few percentage points higher than the Sonic's.

So why drive small? Tiny cars weigh less, so in stop-and-go city driving they require a lot less fuel to get around. Where many 40-highway-mpg cars have much lower city-mpg figures (Hyundai's Accent gets 30 mpg, and the Focus SFE's figure is 28), the puny brigade typically fares far better. The iQ gets 36 mpg in the city, and the Spark should be close. Every car design is a compromise. The trick for those looking to save gas is, first, to figure out where you do most of your driving, and then to choose the car that best matches your profile. — LARRY WEBSTER

SPANNING THE PACIFIC

Major auto shows in Los Angeles and Tokyo closed out 2011. Despite Tinseltown's reputation for glamour, Tokyo's concepts gave that show a far more entertaining, otherworldly feel. Here are some highlights.

2011 Tokyo Motor Show



HONDA EV-STER CONCEPT

The EV-Ster is like Honda's version of the Tesla Roadster—though much smaller and less potent. Honda claims that the RWD electric concept can hit 40 mph in 5 seconds. And thanks to significant use of carbon fiber to save weight, the 10-kilowatt-hour lithium-ion battery pack is good for about 100 miles. This was certainly one of the more stylish cars at Tokyo this year and one we hope makes it to production.

MAZDA TAKERI CONCEPT

Mazda's slick Takeri Concept heralds a rather conventional vehicle, the next Mazda6, a car that will get start-stop engine technology and Skyactiv-D, Mazda's clean-diesel motor that seems to be headed for the U.S. The Takeri's styling is heavily influenced by Mazda's new Kodo design language, which should largely be carried over to the 6. The Mazda6 is set to launch this spring and hit streets in mid to late 2012.

2011 L.A. Auto Show

2013 FORD SHELBY GT500

Just when you thought the "old" 550-hp Ford Shelby GT500 was sufficient to terrorize the tarmac, Ford launches the 2013 model with even more power. Under the hood is a giant 5.8-liter supercharged V-8 that packs a ludicrous 650 hp and 600 lb-ft of torque. Ford says it hits 200 mph. We say, sign us up.



2012 HYUNDAI AZERA

The 2012 Azera plays just one rung below the rear-drive Genesis and Equus sedans in Hyundai's luxury car lineup. Much more stylish than the outgoing Azera, this new FWD offering goes on sale in February with a 3.3-liter direct-injected V-6 that pumps out 293 hp. The Azera's interior is also very roomy, with more cubic feet than the Toyota Avalon.



2013 CADILLAC XTS

A long time coming, the new Cadillac XTS replaces the STS and DTS by splitting their difference in size—yet it has more interior room than the DTS. The car gets a standard 300-hp V-6 six-speed automatic, optional all-wheel drive, Brembo brakes, and active front and rear collision mitigation—a system that steps in and applies the brakes when danger is imminent.



TOYOTA FUN-VII CONCEPT

Toyota's Fun-Vii concept, essentially a rolling computer screen, was one of the oddest vehicles at the Tokyo Motor Show. According to Toyota, the entire vehicle body and interior can be used as a display "to match the mood of the moment." The idea might make sense for commercial vehicles but probably won't have any practical use in passenger cars.

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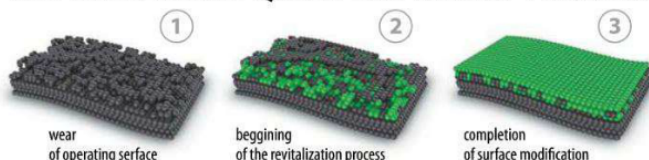
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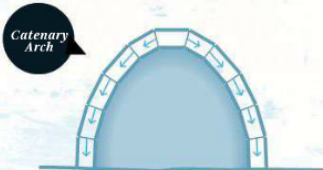
TO LEARN THE SECRETS
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OLD SLEEPS THROUGH THE LAYERS of my clothing as a few lonesome snowflakes skitter from an overcast sky. Everywhere I look there's nothing but ice and snow, a flat, monotonous landscape with the gentle slope of a low hill here and there. By arctic standards, it's a beautiful spring day.

I've come to northern Quebec to learn the art of igloo building at the Nunavik Arctic Survival Training Center, where Inuit instructors teach wilderness skills. The training center is a few miles from here in the village of Puvirnituq, a lonely outpost of 1450 souls on the eastern shore of Hudson Bay. Actually, to call it lonely is an understatement—as you arrive by air, it looks like a tiny island in a sea of white that stretches uninterrupted from horizon to horizon. At least these days it has heated buildings; 50 years ago, most of the community spent the winter in igloos.

Paulusi Novalinga, 56, was born in one. For years he accompanied his father, hunting and fishing in the traditional way and moving across the frozen landscape by dog team. Then times changed. The government built houses, a hospital, a school. Snowmobiles came, and TV, then the Internet. Kids grew up caring more about music than wilderness skills. Novalinga helped found the survival school 12 years ago as a way to reverse the trend. Today he enlists young men from the community to keep the old

the wall to the base, creating a stable structure. According to a study in the December 1973 issue of *Arctic*, a sturdy igloo has a minimum height-to-diameter ratio of 3:10—that is, an igloo 6 feet tall and 10 feet wide (3:5 h/d ratio) is stable, but one 5 feet high and 25 feet wide (1:5) would be in danger of imminent collapse.



DESIGN PRINCIPLES

Sophisticated engineering underpins the design of the igloo. A cross section shows the snow shelter is a

catenary arch that distributes the force of each row of snow blocks to the row below. This compressive force follows the curve of



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ILLUSIKAIION BY DOGG

skills alive by teaching them to outsiders: army personnel, arctic pilots, the occasional tourist.

And now me. Judging by the burning sensation on my exposed skin, the temperature must be around 10 degrees Fahrenheit—it's hard to know precisely, because the Inuit don't seem to own any thermometers. Novalinga leads me a few yards to a sloping hillside. The ideal igloo-building material, he explains, is deep, solid snow that falls in the course of a single storm, so it doesn't have layers that could cause blocks to shear. It should also come from the windward slope of a hill, because the force of the wind packs the snow more densely.

Wielding his *panak*—a homemade machete with an angled handle—Novalinga digs in a few places to find the best spot, then cuts a rectangular hole about the size of a briefcase. Now we're ready to quarry snow blocks. Novalinga hands me the machete and talks me through the process. I make a long slice parallel to the existing cut, then lop off the bottom and sides at an angle. To get the block out, I insert the panak to its hilt in the middle of the long cut and punch downward to pop out the block. It has the texture of dense Styrofoam and weighs about 20 pounds.

Novalinga has me cut block after block until I've excavated a hole the size and shape of a shallow grave. With the machete, he inscribes a circle in the snow about 10 feet across, centered on the middle of the trench. I set my first block upright on his line, then chop the left edge along an imaginary line extended from the center point, haul up another block, cut its right edge to match, and slide them together. It's important, Novalinga says, to not only position the blocks right side up, but with the correct face inward. The Inuit believe



This igloo is the handiwork of columnist Jeff Wise.

HOW TO BUILD AN IGLOO

Northern indigenous peoples build igloos with few tools and the material at hand, eyeballing the angles—a low-tech method that yields an engineering marvel. Norbert E. Yankielun, author of *How to Build an Igloo and Other Snow Shelters*, walks us through the process.

Material: In wind-packed snow, shovel a trench to facilitate cutting the first block. Using a snow knife or snow saw, cut a block 12 inches wide, 24 inches long, and 18 inches deep. Remove the block from the trench and repeat.

Foundation: Mark the center of the igloo with a

stick or ski pole, then trace a circle 6 to 10 feet in diameter. Position blocks along it, using a snow knife to miter the ends for a tight fit.

Construction: Cut a ramp that starts between two blocks and extends halfway around the bottom row. Bevel the tops of the blocks along an imaginary line from the outer edge of

the blocks to the igloo's center (1). Trim snow from the bottom of the blocks in higher rows so they touch only at the corners (2), and bevel the tops along the angle of sight to the igloo's center. Stagger the blocks.

Exit Strategy: Dig an exit tunnel, ideally beneath a downhill-facing wall.

Last Steps: Slide the top block (3) sideways through the opening, turn horizontally, and drop into place. Chink gaps between blocks with loose snow. Poke holes for ventilation.



that if you place the blocks backward, it will summon a storm.

We complete the first row, then spiral the blocks upward, angling them ever more steeply inward as they climb. The work progresses in a steady rhythm: Cut a block, lift it into place, trim the edge to match its

neighbor, then trim the snow away from the middle of the bottom edge by jamming the panak into the joint and working it back and forth. This is the secret rule of igloo architecture: Each block must touch the row below only at its corners. (To understand why, I later consult with John

Ochsendorff, a civil engineering and architecture professor at MIT. "What prevents the new block you've just added from falling out is a line of compressive force that passes through the block to the row beneath," he tells me. Each block acts as a mini arch, creating a line of compression between the top corner of the last block placed and the diagonally opposite corner of the block below.)

I do half the second row, then ask Novalinga to take over so I can snap some photos. In the time it has taken me to place three blocks, he lays down an entire row. I help by cutting more blocks from the floor, and from a section under one wall that will serve as the entrance. Soon he's working overhead, the chips of snow flying and settling onto his face and shoulders as he places the blocks into nearly horizontal positions. I keep expecting the fragile-looking structure to collapse, but the blocks stay glued in place by their own stickiness—adjacent blocks cement together because the snow is constantly melting and refreezing

at a microscopic level.

At last Novalinga maneuvers the final block into place; it's irregularly shaped, like the last bite of a cookie. "That's an igloo!" he says. I look at my watch. We've finished the structure in 3 hours—an eternity for an Inuit igloo-builder. Novalinga has won speed-building competitions in 20 minutes.

Our work isn't quite done. We still have to go around the igloo's dome and stop up holes with carefully shaped plugs and loose chunks of snow, then form the debris inside into a low platform, so that the floor is slightly higher than the bottom of the door opening to keep the warm air from escaping. Inside, we poke holes for ventilation. With a pot of tea bubbling on the Coleman stove, candles burning, and caribou hides on the platform, it's easy to forget that we're encased in frozen water.

For the Inuit, the igloo is hearth and home, the center of their culture. But as a feature of daily life, it's fading from memory. When Novalinga eventually stops teaching igloo making, the skill will pass from the hands of

those who knew it as a living art. "Young people are living in an imaginary world they see on the tube," Novalinga says. "They see the world down south and they can't have it, and they get confused. We're having a culture shock."

Outside, the daylight slowly fades to dark. The igloo glows like a Japanese lantern as the northern lights undulate overhead. Novalinga's nephew, Andrew, will spend the night here with me. I head back inside, and he cuts a block of snow to seal the entrance. (Traditionally, the Inuit built an entrance tunnel, like you see in a children's-book illustration, only when a storm was bearing down.) With my parka still on, I climb into my sleeping bag. It's the first time I've ever spent the night in a room with no door.

Andrew turns off the stove and climbs into his sleeping bag. The air cools quickly. My breath swirls out of my mouth like smoke. I pull the sleeping bag around my face and, as Andrew blows out the candles, fall into a deep sleep.

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Cockpit of the Future

BY JOE PAPPALARDO



WHY CAN'T AIRLINES CATCH UP WITH THE INFORMATION REVOLUTION?

Not all cockpits are created equal. A contemporary Primary Flight Display screen from an airliner (above, left) lacks the terrain details and runway centerline extensions of the synthetic vision systems found in high-end business jets (above, right). Slowly changing federal regulations make it hard for carriers to keep up with emerging technologies—even those that would make flying safer and easier.

As the Falcon 900 business jet emerges through a layer of clouds at 25,000 feet, pilot Sandy Wyatt points at a monitor. “This is what commercial airline pilots see,” he says, referring to the flat screen’s simplistic representation of the airplane’s position: The sky is blue, the land is brown, and the horizon line tilts when the airplane does.

“This is what business-jet pilots can see,” says Wyatt, Honeywell Aerospace’s chief test pilot, gesturing at the screen and toggling to a new flight display. “This is synthetic vision.” The image changes: It’s the same horizon line, but the ground is rendered in vivid 3D. The hills, rivers, and power lines outside Morristown, N.J., roll past as if the canopy of clouds were not obscuring the view. The image is a fusion of GPS, altitude, and airspeed data.

Synthetic vision systems are found only in high-end business jets like the Fal-

con 900. SVS could offer advantages for commercial airliners, enabling pilots to see obstacles from miles away during takeoff or landing emergencies.

But there’s a catch: The Federal Aviation Administration is slow to approve new avionics and even slower to change the rules that govern how pilots fly. These delays cause airlines to shy away from adopting cockpit enhancements, including synthetic vision and satellite-based air traffic control, that could make air travel more convenient and safer.

PHOTOGRAPH BY ARTSTAIN/IMAGES (PRIMARY FLIGHT DISPLAY)

ILLUSTRATION BY VIC KULHIN

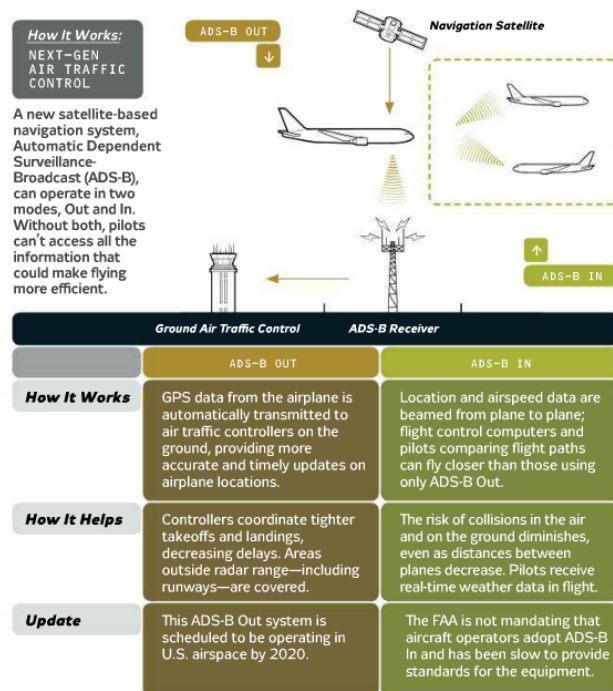
Business-jet makers can commit to the time-consuming, costly FAA approval process. For example, Honeywell began its work on SVS in 2002. The FAA certified its use on Gulfstream business jets in 2008. The wait was worth it: Business jets fly to small airports that are located in rough terrain and have less precise landing infrastructure. The additional awareness of what’s outside made SVS and business jets a comfortable match.

Airlines can’t afford to be patient when it comes to adopting technology across their large fleets. “It’s a business issue more than a tech issue,” says Bob Witver, VP of Advanced Technology at Honeywell. “A major air transport manufacturer said, ‘We like your tech, but we’re selling airplanes to customers who are battling to keep their bottom line healthy. How are you going to help us fly more passengers?’”

The avionics industry responded with enhanced vision systems (EVS) that add infrared camera views to SVS images. EVS enables pilots to land when fog or clouds block their view. If installed on commercial airliners, SVS-EVS would save fuel and decrease delays, the kinds of guaranteed return on investment that airlines need to commit to new cockpit technology.

But the FAA must also approve SVS-EVS for each type of airplane that uses it. This takes time, too: FedEx flight-tested MD-10 airplanes for a year to get EVS certification. No cash-strapped carrier wants to install IR cameras in its fleet and then wait for the FAA to approve them—or possibly not. An FAA committee has spent six years evaluating the use of EVS during landings; its final recommendation is due in July.

Business-jet operators and cargo haulers, who see safety benefits even without a new FAA landing rule, are already buying aircraft with FAA-



certified SVS-EVS. Meanwhile, airline passengers linger at concourse bars and departure gates, wondering why air travel has to be so unpleasant.

Taking Advantage of Radar’s End

As with synthetic vision, FAA management is also slowing the pace of air traffic control modernization. “A majority of the air traffic procedures were designed around technologies from the 1960s and 1970s,” Witver says. “It is safe, but it’s antiquated.”

A new system called Automatic Dependent Surveillance-Broadcast (ADS-B), coming online in the U.S. by 2020, provides precise GPS data from the airplanes to air traffic controllers. ADS-B enhances efficiency by letting the controllers line up (or “stack”) planes near airports.

The aviation industry is clamoring for direct communication between airplanes, not just between the planes and the ground. Collision avoidance sys-

tems could allow even tighter stacking. Real-time weather data could help pilots dodge storms. Airplanes could adjust speeds to arrive when planned, easing airport congestion. But the FAA is not mandating plane-to-plane connectivity, though the ADS-B datalinks can be adapted to receive information.

FAA spokesmen say the agency has released some preliminary standards, but experts say that they’re not enough. “Those pieces are critical, but there is a lack of commitment to an overall plan,” says former FAA adviser Hans Weber. “There are no timetables and no specifications for avionics suppliers to build to.” Weber says the FAA has been hobbled by union politics and a Congress that has produced 22 temporary budgets in the past four years.

Until the FAA can figure out a way to streamline its approval processes and get some steady direction from Congress, air travel will remain frustrating. Unless, of course, you fly around in a business jet.

My Next McLaren

> BY JAY LENO
> PHOTOGRAPHS BY JEREMY HART

"DON'T BE AFRAID TO STAND ON THE BRAKES."

No matter how many times McLaren's chief test driver, Chris Goodwin, recited these instructions, the message just didn't compute. This was back in 2009 on a test drive of a preproduction model of McLaren's newest road car, the MP4-12C. Try as I might, I couldn't get my head around the insane capabilities of the car. All I knew was that I had to have one.

I shouldn't have been surprised; I love driving my 1994 McLaren F1. It was the British company's first road car, and almost two decades later, it still stands as one of the world's best sports cars. Only 106 were built before production ended in 1998.



While tearing around the Top Gear test track in Surrey, England, Jay never once felt like he was in danger of losing control of the preproduction McLaren MP4-12C—even when he was almost sliding off the track.



MORE CAR THAN ANYONE NEEDS, McLAREN'S MP4-12C IS ONE RIDE JAY HAS TO HAVE.

The F1 was a rare diversion from the company's main objective: winning races. (In fact, a racing version of the F1 won the 24 Hours of Le Mans in 1995.) Bruce McLaren was an extremely talented driver who formed his own team in 1965 and went on to win numerous Can-Am championship and Formula One events. McLaren was killed while testing a Can-Am car in 1970, but his company survives under the leadership of Ron Dennis, the famously detail-obsessed former mechanic who once said, "Dust can be eliminated." Dennis has shaped McLaren into one of the world's foremost automotive technology companies. The MP4 is his baby.

Like the F1, which was the first production car with a carbon-fiber monocoque as the main structural component, the MP4 has a passenger compartment made from a one-piece carbon-fiber "tub." Gordon Murray, the F1's designer, says that the MP4's tub costs about \$10,000—one-tenth of the F1's. Sections of the MP4's tub are hollow, which makes it an extremely lightweight 176 pounds. I double its weight just by sitting in it. The tub is bookended by two aluminum subframes that carry the midmounted engine and gearbox and the front crash structure. Because the body is only a shell, you can drive the chassis like it's a big, expensive go-kart.

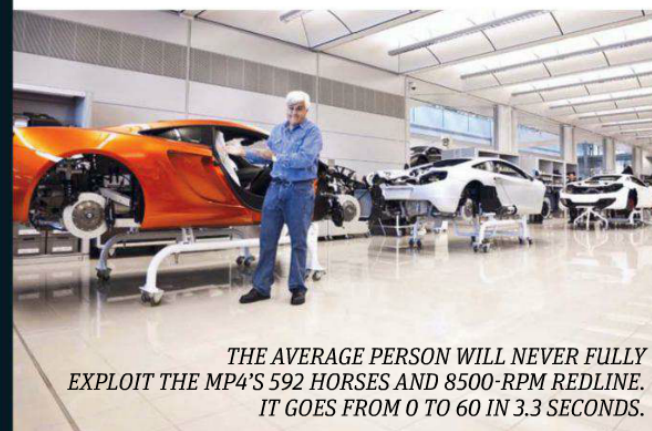
McLaren designs cars differently

from other sports car companies. Bugatti, for example, first created the Veyron's body and then fit everything in it, so it's kind of bulbous and big. McLaren designs the mechanical and electrical systems first and then constructs the body around them, ensuring that the body is exactly what it needs to be—no more, no less. Some people who like the angular F1 aren't crazy about the curvy MP4. Personally, I like the MP4's subdued styling. Maybe that's the Scottish in me. I'm not a big fan of cars that look like flying insects, especially when you're an older guy. How many times have you seen an older guy get out of a red Ital-

nally and from side to side. A cockpit switch adjusts the damping force by changing the size of orifices in the hydraulic lines.

There are three suspension settings: Normal, Sport, and Track. With most sports cars, it's hard to tell the difference. Not so with the MP4. You can dial in Normal for a boulevard ride, as we used to call it back in the '50s. When you hit Track, the car's personality changes completely, hunkering down and digging into corners like nothing I've ever driven, pinning me sideways in the seat with the force of a silverback gorilla.

The Track setting also makes the exhaust really loud. Belting out the noise is a 3.8-liter twin-turbo V-8 developed by Ricardo. Huge body scoops feed two side-mounted radiators. The transmission is a seven-speed dual-clutch automated manual. The average person will never fully exploit the MP4's 592 horses and



THE AVERAGE PERSON WILL NEVER FULLY EXPLOIT THE MP4'S 592 HORSES AND 8500-RPM REDLINE. IT GOES FROM 0 TO 60 IN 3.3 SECONDS.

ian sports car with a big wing on it, and women go, "How old are you?"

The suspension in the MP4 is McLaren's own design, with some innovative twists. Unlike every other sports car, the MP4 doesn't use anti-roll bars or conventional shock absorbers to control wheel movements. Instead, hydraulic struts at each corner are linked via tubes running across the chassis, both diagonally

The McLaren Technology Centre in Woking, England, is the most technologically advanced car factory Jay has ever visited. It's immaculate—like a hospital for cars, he says.

8500-rpm redline. The car goes from 0 to 60 in 3.3 seconds, one-tenth quicker than a Ferrari 458. When Formula One drivers compare the McLaren MP4 and the Ferrari 458 for acceleration to 180 mph, they're looking for differences of one-tenth of a second. I can't even begin to do that.

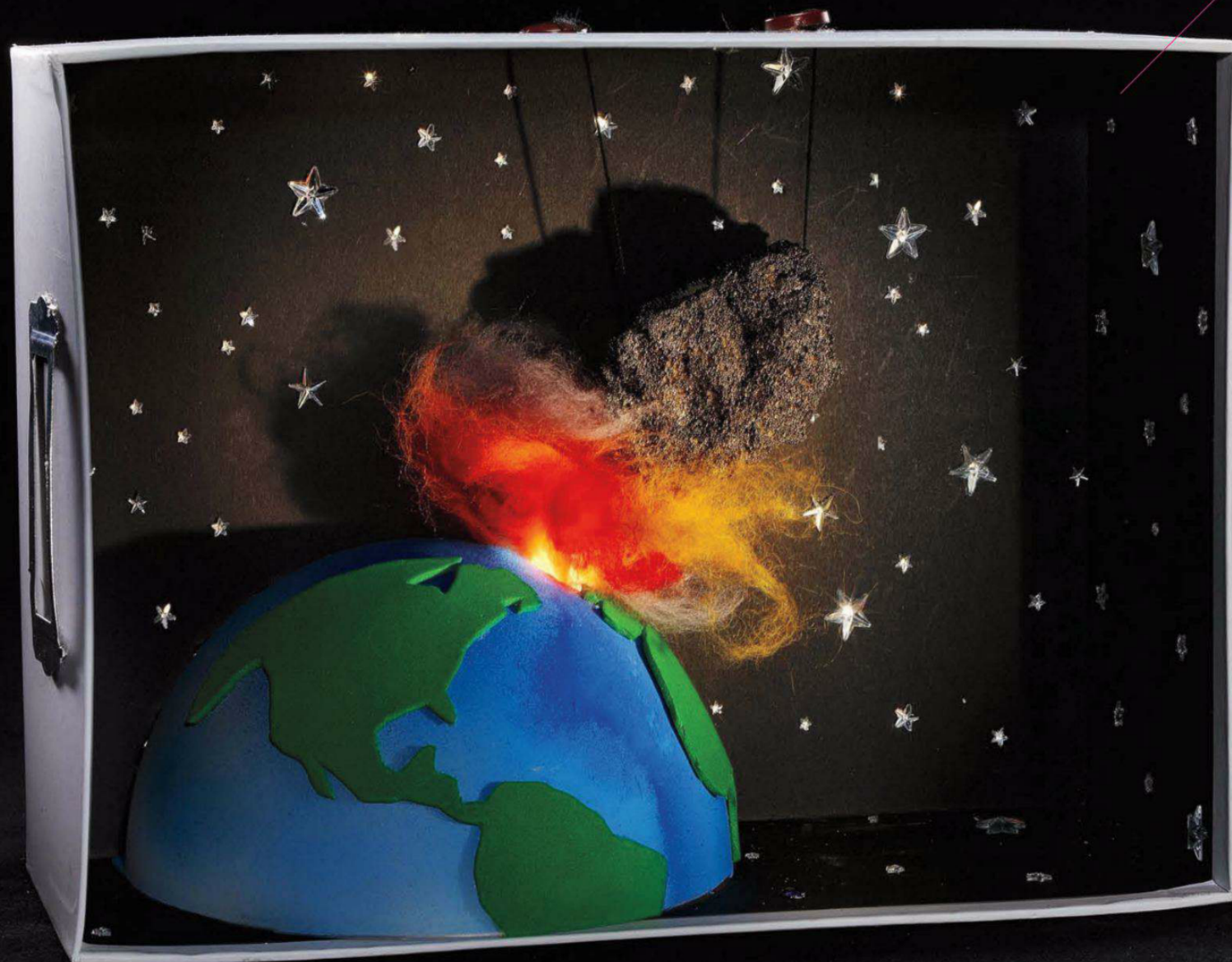
And that's why Goodwin had to keep telling me to pound on the brakes. My frame of reference might as well have been from another planet. Although I own and drive my fair share of sports cars, I also drive old cars with brakes that fade after comparatively light use. Take my '55 Packard Caribbean, for example. One day I'm flying along Mulholland Drive in it, making the old car handle nicely, hitting the brakes in the corners, and then I see a stop sign. I mash the brake, the pedal goes straight to the floor, and I go right through the intersection. If anyone had been coming, I'd have been dead.

But with the MP4 (or any McLaren, for that matter), the brakes never fade. Knowing there's always extra performance waiting to be explored makes the car exciting to drive. I like that the MP4 is not meant to be a showpiece. Even with features like dihedral pop-up doors and sophisticated electronics, the MP4 is a mature car in the sense that you can use it every day, in the style of a Porsche 911 or a Corvette. Most Italian sports cars tend to be the weekend-only variety, which is fine, but very few people can afford a supercar just for weekend jaunts. Even though the MP4 is expensive—there's no way any car that costs \$231,140 isn't expensive—it's not on the out-of-this-universe level like the \$1 million F1 or the \$670,000 Ferrari Enzo. For McLaren, this is an entry-level car, and they expect to sell about 1000 of them the first year, once it goes on sale this winter.

I like a car that's one man's vision from start to finish. The F1 was Gordon Murray's vision. He didn't use a radio, so you didn't get a radio. The MP4-12C is Ron Dennis's idea of what a car should be. It's relatively simple, and it goes crazy fast. That's what I like. And that's why I can't wait until my MP4 arrives.

PM

FIGURE 1:
ASTEROID IMPACT



BY JEFF WISE
PHOTOGRAPHS BY DAN SAELINGER
MODELS BY MEGAN CAPONETTO

That's All Folks ...

Could the world end in 2012? Put aside the goofy prophesies of Mayan calendar doomsayers and join us on a journey into the cold, hard science of civilization-ending catastrophe.

PREDICTING THE END OF THE WORLD IS BOTH A sure bet and a fool's errand. Eventually, the total destruction of civilization, the human race, and, indeed, the world is a near certainty. The tricky part about predicting the apocalypse is the timing. But that hasn't stopped people from forecasting impending doom throughout human history. Holy men, ancient astronomers, and even modern computer scientists have all occasionally read the leaves in their occupational cups of tea and concluded that the end is nigh. And, without exception, they have all been wrong.

But maybe this year is going to be different. On Dec. 21, 2012, the Mayan calendar will reach the end

➔
READ
ON

of a 394-year cycle called a *b'ak'tun*, which has sent end-time aficionados into a frenzy. (About the movie based on the 2012 theory, the less said the better.) Archaeologists laugh off that doomsday scenario, explaining that the Mayan calendar cycle is no more momentous than our own calendar ticking over from 1999 to 2000. So that's a relief.

Still, just because the Mayans didn't predict the end of the world this particular year doesn't mean our safety is assured. There are plenty of other risks to life on earth that scientists do take seriously. These might range from disasters that threaten millions or billions of people to an all-out "extinction-level event" that wipes out the majority of life on the planet.

Could one of these global bums strike this year? Not likely. But not completely impossible. To understand the infinitesimally small—but nonetheless real—risk of planetary disaster, it helps to travel back in time. Because such events have happened before. And the results weren't pretty.

To see the evidence, let's take a trip. Start with a visit to the American Museum of Natural History in New York City. On the fourth floor, just inside the entrance to the Hall of Saurischian Dinosaurs, you'll find a chunk of Montana dirt with dark and light bands layered like Neapolitan ice cream. Not very exciting compared to the huge creatures on display nearby. But one thin, grayish-beige layer might explain what exterminated these great beasts: It's the impact residue of a 6-mile-wide asteroid that struck the Yucatán 65 million years ago. "In its aftermath we see extinctions of everything from single-celled organisms to the largest dinosaurs," says Mark Norell, chairman of the museum's paleontology division. Could another one seal our own fate? Or could some other extraterrestrial catastrophe bring us death from above?

Or maybe it could come from below. Twenty-two hundred miles west, in Yellowstone National Park, one of America's most popular tourist attractions, is another ominous harbinger of destruction. About once every hour, the pool around the Old Faithful geyser explodes in a fountain of spray 145 feet tall. It's a cool effect, until you consider what powers it: geothermal energy radiating up from a subterranean plug of magma. Every 500,000 years or so, the Yellowstone supervolcano erupts and rains lava and ash for hundreds of miles. An eruption 250 million years ago in Siberia may have released enough carbon into the atmosphere to cause the largest mass extinction in earth's history, the Permian-Triassic, which wiped out 96 percent of all sea life.

In the cruelest of ironies, the gravest threat to human life on earth may be other life on earth—the microbial kind. Let's turn our tour of all things apocalyptic to the Netherlands, where virologist Ron Fouchier at the Erasmus Medical Center recently synthesized an airborne version of the H5N1 avian flu. The lethality and frequent mutations of H5N1 make it a serious pandemic threat. The last big influenza pandemic, the Spanish flu of 1918, is estimated to have killed more than five times as many people as World War I. The possibility of a naturally occurring global outbreak is ever present, but the threat from labs is becoming more

frightening. "The cost of synthesizing a new organism goes down every year," says Dr. Ali Khan, head of the Office of Public Health Preparedness and Response at the Centers for Disease Control and Prevention. "A bad guy could make his own smallpox."

Although imminent destruction seems all around us, the probability of extinction in any one year is vanishingly small. Our long-term prognosis, however, is far darker. Very few species survive through the eons like the alligator and the coelacanth. "The safe bet is that we won't make it, because 99.9 percent of things don't," says Timothy Spahr, director of the Minor Planet Center in Cambridge, Mass., an asteroid- and comet-tracking organization.

We've got some time, though. On average, vertebrate species stick around 4 to 6 million years, and modern humans are only about 200,000 years old. And we're not your typical vertebrates. Our science and technology might ultimately migrate off this little planet altogether. So maybe we're just getting started.



Asteroid Impact



THE 62-MILE-DIAMETER MANICOUAGAN CRATER (NOW A RESERVOIR) IN QUEBEC, CANADA, WAS FORMED FROM THE IMPACT OF A 3-MILE-WIDE ASTEROID 215 MILLION YEARS AGO.

SPACE OBJECTS STRIKE THE EARTH ALL the time, but extinction-level impacts occur only once every 100 million years. After the spectacular collision of the Shoemaker-Levy 9 comet with Jupiter (and a host of asteroid-disaster flicks) in the 1990s, NASA set out to map all large near-earth objects. But it appears that there are far fewer potential catastrophes in earth's neighborhood than once thought. "A civilization-killing asteroid would have to be a mile across," says Spahr of the Minor Planet Center. (The space rock that ended the dinosaur era is estimated to have been six times that size.) "There just aren't any asteroids that size out there," he says.

There is, however, a large population of as-yet-undiscovered objects several hundred yards across. One that we do

EPIDEMIOLOGISTS HAVE KEPT A CLOSE EYE ON AVIAN INFLUENZA (H5N1) BECAUSE OF ITS LETHALITY. SO FAR THERE HAVE BEEN LIMITED TRANSMISSIONS FROM BIRDS TO HUMANS, BUT THE DISEASE IS EVOLVING FASTER IN THE LAB THAN IN THE WILD—LAST NOVEMBER A DUTCH SCIENTIST CREATED AN AIRBORNE STRAIN THAT COULD BE FAR MORE CONTAGIOUS TO HUMANS.



know about, a 300-yard-wide asteroid called 99942 Apophis, will pass within the orbits of earth satellites in 2029 and could one day strike the planet. **"Worst-case scenario?" Spahr says. "You hit Los Angeles, kill millions of people, and shut down the entire West Coast."**



Pandemic

FOR A DISEASE TO BE GLOBALLY DISRUPTIVE, it must undergo a flare-up of contagiousness and lethality—like the 1918 influenza pandemic, which in the course of two and half years killed 50 to 80 million people. If the next influenza pandemic is as bad as 1918's, the equivalent toll would be 210 million. "Knocking off that many people at once would disrupt civilization," the CDC's Khan says. He adds, however, that in the past century medical science has developed powerful weapons against disease. **"We're an intelligent species," he says. "We can fight back."**

But what if that intelligence were turned against us? Thanks to advances in biotechnology, it will become increasingly possible to custom-tailor a pathogen's lethality. "We're on the cusp of

what could be a very frightening time," says Charles P. Blair, director of the Terrorism Analysis Project at the Federation of American Scientists. "I think in the very near future you're talking about a potential extinction event."



The Machines Take Over

MOORE'S LAW—THE OBSERVATION THAT COMPUTER CHIPS GET TWICE AS powerful every two years—implies that, eventually, artificial brains will eclipse the human brain. The big question is, what will the artificial superintelligence of the future choose to do with its gifts?

"The risk is not so much a *Terminator* scenario, where you get a super-computer that dislikes humans," says Anders Sandberg, a researcher and futurist at the Oxford Martin School's Future of Humanity Institute in England. "A malign neglect would be a bigger problem. You get something that's very intelligent but has motivations that are completely non-human. [The computer] might not really care about anything that we care about, but since it's smarter, it's going to get what it wants."



Gamma-Ray Bursts

WHEN LARGE STARS DIE, THEY GO OUT IN SPECTACULAR FASHION. HAVING used up their nuclear fuel, their cores collapse inward into a black hole, which then devours the star from inside out. Out of this paroxysm of destruction, powerful beams of energy burst from both poles, shooting gamma rays and charged particles that for a few seconds outshine the rest of the stars in the universe combined.

That's great for astronomers, who can observe these gamma-ray bursts, or GRBs, from across the universe—but not so good for any planet that happens to be located in the path of the beams. **In a one-two punch, a bath of charged particles would quickly kill everything on one side of the planet while intense gamma rays would ionize the atmosphere and cause years of acid rain.**

"As a rule of thumb, the danger zone extends to anything within 3000 light-years," says Penn State astronomer Derek Fox, who specializes in gamma-ray bursts. But for us, he says, "it's not a likely threat." The average galaxy experiences a GRB only every 10 million years or so, and the danger zone is a small percentage of that galaxy.



Snowball Earth

RIGHT NOW PEOPLE WORRY ABOUT GLOBAL WARMING, BUT FALLOUT FROM a nuclear war or a supervolcano could put enough sunlight-blocking dust in the air to cause the opposite problem: a deep plunge in surface temperatures. If the earth stayed cool long enough, a worse catastrophe could ensue.

Back in the '60s, climate modelers realized that if the earth were covered in enough ice, most of the incoming solar radiation would be reflected back into space and the planet would settle into a stable state at about minus 50 degrees F. Then, in 1992, CalTech geobiologist Joseph Kirschvink proposed that the earth had once spent long stretches of time

almost entirely frozen over, leaving evidence of glacial deposits in the tropics. Life clung on in a few sanctuaries heated by volcanic springs.

Could it happen again? **"It's not something you'd need to worry about next year, or the next hundred years," Kirschvink says.** "Even if the climate became very cold, it would take a long time for glaciers to build up."

Ocean Acidification

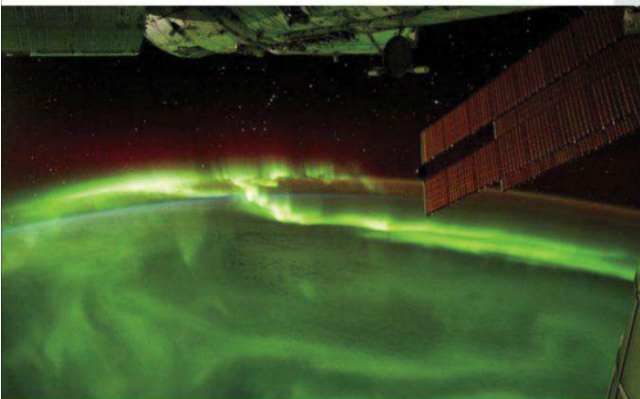
TEN MILLION YEARS AFTER THE DINOSAURS DIED, CARBON DIOXIDE LEVELS in the atmosphere soared. The oceans absorbed CO₂ and became increasingly acidic, triggering a wave of extinction that swept the planet.

Today, carbon dioxide levels are again soaring—but this time, they're rising 10 times faster. Earth scientist Andy Ridgwell of the University of Bristol in England has modeled the effects of rising CO₂ levels and says the damage could be most visible in coral reefs. Not only would reef destruction result in a loss of habitat for an estimated 25 percent of marine life, it could also expose many coastal cities to greater storm and wave damage. "If [the reefs] vanish, or largely vanish, that will be a real economic, social, and environmental catastrophe," Ridgwell says.

Nevertheless, it doesn't seem as if acidification is an immediate threat to human life. It would take a severe toll on deep-water species of plankton, but it would largely spare the world's major commercial fisheries. **"A lot of things that are at risk of extinction we might not even notice," Ridgwell says.**

Solar Storm

LATE LAST YEAR A MAJOR SOLAR STORM LAUNCHED A WAVE OF CHARGED particles through the solar system at 4 million mph, setting the stage for



THIS IMAGE FROM THE INTERNATIONAL SPACE STATION SHOWS AN AURORA FORMED BY STRONG SOLAR STORMS LAST FALL. THESE BURSTS OF CHARGED PARTICLES CAN WEAK HAVOC ON ELECTRICAL EQUIPMENT ON THE GROUND—AND A NASTY STORM COULD SHUT DOWN MUCH OF THE TECHNOLOGY THAT RUNS OUR MODERN WORLD.

a display of northern lights that could be seen as far south as Arkansas. But while delightful to the eye, such a storm could someday herald disaster.

The earth's magnetic field prevents the sun's deadly particles from striking the surface. The motion of those particles, however, can induce strong currents on the ground. During the worst solar storm ever recorded, in 1859, the currents were so intense that telegraph lines burst into flames. **"If we had a storm like that today, it would be possibly quite catastrophic,"** says Jeffrey Love, a geomagnetic researcher with the U.S. Geological Survey. **"Months without electricity could cause losses of trillions of dollars and basically wreck the economy."**

Supervolcano

TWO MILLION YEARS AGO, A MASSIVE VOLCANIC eruption near what is today Yellowstone National Park shot 600 cubic miles of dust and ash into the atmosphere—2400 times more than Mount St. Helens did in 1980. If such an eruption happened today, "it would greatly interrupt business as usual around the planet," says Jake Lowenstern, a geologist with the U.S. Geological Survey and scientist-in-charge at the Yellowstone Volcano Observatory. Aside from the toll in human lives in the vicinity of the eruption, he says, "global air traffic would be interrupted for months, if not years."

Since that ancient blast, massive eruptions have been taking place every 600,000 years or so—and the last one was 640,000 years ago. On the bright side, the intervals between the Yellowstone supervolcano's eruptions are extremely erratic. Statistically speaking, it's very unlikely to blow in 2012, or even within the next millennium.

Geomagnetic Reversal

RIGHT NOW, THE MAGNETIC NORTH POLE is up near the rotational north pole, but this hasn't always been the case. Throughout the earth's history, the north and south magnetic poles have swapped places, a phenomenon known as geomagnetic reversal. It happens irregularly, every 100,000 to 1 million years, and the last time they flipped was 780,000 years ago. So maybe we're due. Geophysicist J. Marvin Herndon has suggested that the reversal could cause the geomagnetic field to temporarily collapse, disrupting everything from power



FIGURE 2:
SUPERVOLCANO



"THE ERUPTION OF A SUPERVOLCANO WOULD BE HIGHLY DISRUPTIVE. IF THE WORST-CASE SCENARIO WERE TO HAPPEN AT YELLOWSTONE OR ELSEWHERE IN THE WORLD, IT WOULD CHALLENGE OUR ABILITY TO RUN CIVILIZATION. BUT IN TERMS OF THE ENTIRE EARTH, ANY ONE SUPERVOLCANO EVENT IS STILL UNLIKELY TO CAUSE A MASSIVE EXTINCTION."

— JAKE LOWENSTERN, SCIENTIST-IN-CHARGE, YELLOWSTONE VOLCANO OBSERVATORY



"NUCLEAR WAR IS A CONSTANT POSSIBILITY. NOT A BIG ONE, BUT ENOUGH TO BE A SERIOUS THREAT. THERE HAVE BEEN ENOUGH EVENTS OVER THE PAST 66 YEARS—including the Cuban Missile Crisis and periods of serious tension between India and Pakistan—to make me think that the probability might well be above 1 percent per year."

— ANDERS SANDBERG, FUTURE OF HUMANITY INSTITUTE, OXFORD MARTIN SCHOOL



FIGURE 3:
NUCLEAR WAR

grids to gas pipelines to communications satellites.

But there's also no need for immediate panic. While a flip would occur quickly on a geological time scale, it is far longer in human terms, between 1000 and 10,000 years. "Whether it's going to do us harm is an academic question," says Jeffrey Love of the U.S. Geological Survey, "because it's not going to happen tomorrow, and it's not going to happen in our lifetime."



Nuclear War

ON SEPT. 26, 1983, A SATELLITE-MONITORING unit at a secret facility near Moscow received a warning: Five nuclear missiles had launched from a base in the U.S. Luckily, the unit's officer, Stanislav Yevgrafovich Petrov, was skeptical about the reliability of newly installed equipment, and he chose to wait rather than immediately pass along an alarm that might trigger a nuclear war. His judgment may have saved millions of lives.

Nuclear tensions have subsided considerably since the end of the Cold War. But the threat remains. More countries than ever have the bomb, and terrorist groups and rogue states remain a worry. A study published in 2008 by the journal *Physics Today* suggests that a regional war involving as few as 100 bombs could cause a nuclear winter, resulting in the lowest temperatures in 1000 years, while an exchange involving thousands of weapons would, the study concluded, "likely eliminate the majority of the human population."

"Nuclear war is the near-term risk that people tend to forget about," says Sandberg of Oxford Martin. "If you think historically, we've probably been very lucky."

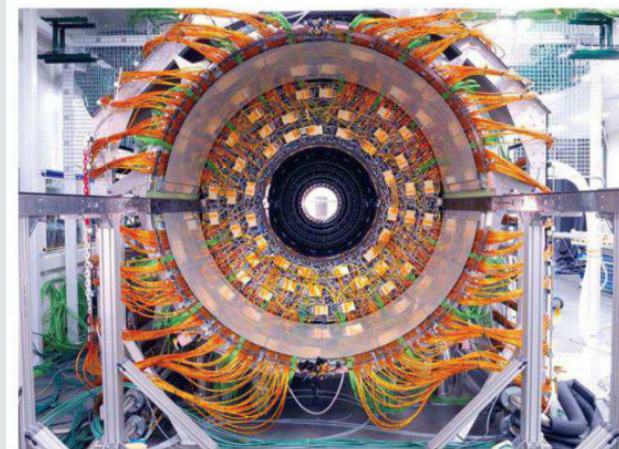


Artificial Black Hole

IN 1945, A PHYSICIST WORKING ON THE first atomic bomb raised a disturbing possibility: What if the energy released by the fissioning nuclei ignited the atmosphere and wiped out life on earth? Obviously, that didn't happen, and mankind survived its entry into the nuclear age.

But the notion that physicists could unwittingly trigger a world-ending catastrophe has not gone away. In 1999, as the Brookhaven National Laboratory prepared to fire up its Relativistic Heavy Ion Collider (RHIC), a Hawaiian man named Walter Wagner filed a lawsuit to have the facility shut down. He claimed that the collision of high-energy subatomic parti-

MOST SCIENTISTS DISMISS THE POSSIBILITY THAT THE LARGE HADRON COLLIDER, NEAR GENEVA, COULD TRIGGER MAN-MADE BLACK HOLES.



cles could spawn tiny black holes that could subsequently grow until they swallowed the earth.

In more than a decade of operation the RHIC has not produced a black hole, but Wagner is currently warning of the same danger for Europe's Large Hadron Collider, which is generating yet higher energies.

Mainstream physicists dismiss the threat. "This danger simply does not exist," says Brookhaven Lab physicist Dmitri Kharzeev. "These energies are high in human terms, but the cosmic rays that naturally occur in space are much more energetic. If high-energy particle collision could produce black holes, one would have swallowed us a long time ago."

The X Factor

ANY OF THE THREATS HERE WERE INCONCEIVABLE A CENTURY AGO. Are there other dangers lurking beyond the fringes of our understanding? Some scientists working on the cutting edge of cosmology have suggested ideas that sound bizarre but one day may be accepted as real.

One is the notion of "vacuum decay," the idea that space itself might shift to a different quantum state, vaporizing everything in it. Another is the theory that structures existing beyond the visible dimensions, called branes, could collide, with equally apocalyptic results.

To astronomer Derek Fox, this kind of thinking is more thought-provoking than disturbing. "Yes, it's possible that there are things out there in the universe that could be a threat to life on earth that we don't know about yet," Fox says. "But I don't think these are the things that we need to be most worried about. Every night astronomers are looking into the universe, looking back 10 billion or more years into the past, and they've never seen any signs of these sorts of things."

DIY

AND SAVE

BY BRETT MARTIN // ILLUSTRATIONS BY ANGIE WANG

WHERE THERE'S A WILL (AND A LITTLE SKILL) THERE'S A WAY TO CUT THE COST OF HOME UPGRADES. HERE ARE 10 PROJECTS TO HELP YOU KEEP MORE CASH ON HAND. PLUS: HOW TO KNOW WHEN TO CALL IN A PRO.

1

GRIND AWAY A STUMP

Difficulty vs Satisfaction



A pro knows how to subdue stumps and roots using unwieldy machinery. An expert can grind a 20-inch stump down to 6 to 8 inches below ground in about 30 minutes. "You don't want an ugly stump sitting there," says Linda Morrow, co-owner of Gene's Stump Grinding Service in Wichita, Kan. "It's extra work to mow around it."

You can do it if you rent a stump grinder (about \$87 for 4 hours) and contain the wood chips and dirt. Morrow sets up a plywood barricade. ("Debris flies everywhere," she says.) Wear gloves, boots, goggles, and earplugs.

Pro's cost: \$2.50 to \$4.50 per diameter inch

DIY savings: Grinding two 3-foot stumps with a 4-hour rental nets at least

\$93

2

SEAL AN ASPHALT DRIVEWAY

A pro knows how to remove tough oil stains by burning them off with torches before seal-coating. Pros also have access to commercial-grade sealers that contain more latex than those sold to DIYers at home centers. "The extra latex gives it a longer-lasting, more durable finish. We also add sand, which provides better traction," says Arthur Alexander, owner of Midlothian Paving in Powhatan, Va.

You can do it if you can master the sealant brush, which resembles a push broom paired with a squeegee, to evenly apply the sealer. "Squeeze out heavy lines or buildup," Alexander says. Repair fissures with a crack filler, scrub oil stains with a liquid laundry detergent, and add a pound of silica sand per gallon of sealant. (But leave the torching to a pro!)

Pro's cost: 20 cents per square foot

DIY savings: For 1500 square feet, you could pocket

\$240

Difficulty vs Satisfaction



3

BUILD A CLOSET STORAGE SYSTEM

A pro knows how to factor in odd shapes and angled ceilings to create a design that maximizes utility. A familiarity with useful accessories helps. "We can install lots of bells and whistles, like ironing boards that pull out of drawers, and tie racks," says Mike Musick, owner of the Custom Closet Company in Auburn, Wash. "With tall ceilings, we can install racks that pull down so you don't need a ladder."

You can do it if your jigsaw skills are sharp enough to precisely trim shelves to span from one out-of-square wall to another. Musick suggests doing a bit of research into standard rod and rack heights to keep clothes from dragging on the floor. To make a sturdy shelf that can take a lot of weight, Musick recommends laying 1/2-inch plywood atop three level 1 x 2 cleats.

Pro's cost: \$85 per linear foot, plus \$85 per drawer

DIY savings: A 10-foot-wide closet could tuck away up to

\$2300

Difficulty vs Satisfaction



4

HANG A CEILING FAN

A pro knows how to safely install new electrical cable to an open spot on a ceiling. Electricians can also evaluate the breaker panel to see which circuits will handle the new load. "We know the codes, which are very strict," says Tony Wilcoxon, a service technician for Discount Electric in Fremont, Calif. Another detail a pro can nail: the need to securely mount fan-rated electrical hardware to hold the heavy, gyrating weight.

You can do it if you don't have to run new cable but rather are replacing an old light fixture with a fan, switch, and a fan-rated electrical box. "The job is a lot easier if you have access to the ceiling from above," Wilcoxon says. Just be sure to walk on joists only, so you don't step through the ceiling. Oh, and turn off the circuit breaker for the wires you're connecting. Safety first!

Pro's cost: \$185 (using existing wiring) to \$350 (running new wire)

DIY savings: As much as a cool

\$350

Difficulty vs Satisfaction



< Part push broom, part squeegee, the asphalt-sealant brush dresses a driveway in the finest latex finishes.

Tom Potter from the New York Distilling Co. checks his still. His spirits begin as a sugary soup that undergoes intermolecular disruption and violent reconstitution on a long, hard journey to the bottle.

WHISKEY REBELLION

THE PIONEERS OF CRAFT DISTILLING
USE OLD METHODS AND NEW
MACHINES TO REVIVE LOCAL SPIRITS.

by WILLIAM GURSTELLE
photographs by CAMERON KRONE

At

12:32 pm

on a warm November day in Brooklyn, N.Y., the first drops of clear alcohol drizzle from America's newest still. Nick Haase, a slender technician from the still manufacturer Christian Carl Distilleries, kneels to collect the drippings in a plastic pitcher set on the concrete floor. Above him looms a copper kettle studded with gauges, bolts, and portholes; a pretzel of iron pipes; a steel catwalk; and the corrugated-metal peaked roof of a cavernous 5000-square-foot barn in the shadow of the Brooklyn-Queens Expressway. Haase keeps rubbing the liquid between his fingertips and smelling his hands, waiting for the sweet odor signaling that the distillate has passed from its oily, aldehyde-heavy first phase into the usable fruits of the labor, known in distiller jargon as hearts. At 12:48, it happens.

"I will be so bold as to taste it," Haase says. Although it's the first hooch ever to emerge from this still, Haase has the confidence that grows from having set up more than 60 similar machines in America. He cuts the hearts with tap water, sips it, and pronounces it hot, meaning, it's heavy on the ethanol. He passes the cup around to the still's proprietors. "Call me nuts," contractor Rob Herschenfeld says, "but that tastes a lot like alcohol."

Nevada, Samuel Adams, and his own Brooklyn Lager, were just beginning their sales boom. Now Potter and partner Allen Katz see this story playing out again, but with spirits replacing ales and lagers. Beginning with Perry's Tot, a stout 57 percent alcohol by volume (ABV) Navy-strength gin, and a mellow, hibiscus-infused 44 percent ABV gin called Dorothy Parker American Gin, Potter plans to establish the NYDC as the hub of a distilling operation that teams up with a distillery in the Hudson Valley in Warwick, N.Y., as well as with his old pals at the Brooklyn Brewery. "We're going to do a little bit of everything here," Potter says. The open-to-the-public distillery will span the process from mash tuns to cocktails in an adjacent barroom.

Because they have the ability to work slowly and in small quantities, Owens says, independent distillers can control details as particular as the provenance of botani-

The maiden booze run at the New York Distilling Co. (NYDC) uses 21st-century technology to complete a chemical reaction that has changed very little in hundreds of years. At roughly the same time man devised the longbow, people began distilling alcohol from grains and fruits. The taste, the smell, the feeling after imbibing a wee dram—it's basically the same thing a kilt-clad Scots Highlander would have experienced while riding with Robert the Bruce.

But alcohol today, like most of what Americans consume, typically emerges from gigantic, antiseptic, computer-controlled megafactories. In response, outfits like the NYDC satisfy a growing appreciation for things made by hand. Limited-run, small-batch manufacturing, using carefully selected and often local ingredients, is gaining traction among consumers in search of authenticity and character. One manifestation of that trend is the craft distillery, a raw work space filled with alembics, coils, vats, and the smell of cereal and fermentation. Twenty years ago about 60 legal U.S. microdistilleries—those producing less than 65,000 gallons a year—existed; today there are 300-plus, with dozens more emerging each year, according to Bill Owens, founder of the American Distilling Institute. Such artisans are among the most hardcore do-it-yourselfers on the planet, constantly figuring out ways to reclaim the skills and methods nearly lost to mass production. They work in hope that their ingredients and talents lead to something distinctive—something that allows them to grab a toehold against fierce competition from established industry titans.

A partner in the NYDC, Tom Potter, got his start as a small-batch manufacturer when he co-founded the Brooklyn Brewery in 1987. At the time, small breweries were popping up all over the country. Craft beers, such as Sierra

How Distilling Works

Operating an unlicensed DIY still is illegal in the U.S. But the process always obeys the laws of fractional distillation—a difference in boiling points is the secret to separating ethanol from water.

1 The Fermenter

The distiller mixes yeast, water, and sugar (or a sugar-containing grain) in a fermenter, aka a mash tun. After three to seven days of voraciously fermenting, the yeast has consumed most of the sugar, turning the mash into a wash (10 or 12 percent alcohol by volume). A pump moves the wash into the pot of the still.

2 The Pot

A boiler pumps steam into a jacket, or two-walled metal sleeve, that surrounds

the bottom of the pot. The heat builds for a half-hour or so to raise the wash to its boiling points—plural. Ethanol boils at 173 degrees F; water at 212.

3 The Distillation Column

As blended alcohol and water vapor rises from the pot, it enters a cool copper column. Most of the vapor condenses and falls back into the pot as reflux. Flat copper condensing plates can span the column, controlling the pace of the process (and the taste of the product). The vapor

with the highest alcohol content, and thus the lowest boiling point, continues to the outlet at the top of the column.

4 The Lyne Arm

Concentrated alcohol vapor enters a horizontal pipe called a lyne arm. Precise heat is key. Too hot and the vapor contains excess water; too cool and not enough vapor enters the arm.

5 The Condenser

Vapor in the lyne arm flows into a vertical

chamber, where a pipe of cool water surrounds a pipe of alcohol vapor. As vapor cools, it condenses into liquid ethanol, which drips from the condenser into a collection vessel.

6 The Distillate

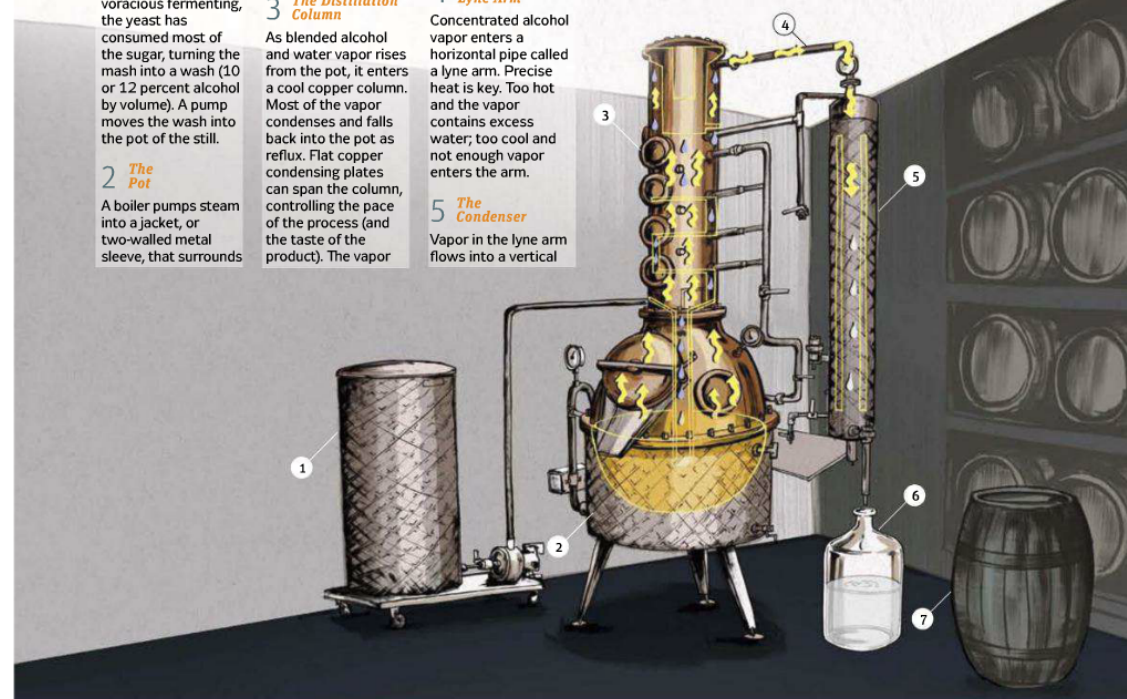
The first 5 percent of the run, aka the foreshots or heads, contains large amounts of congeners, or volatile chemical compounds such as acetone, aldehydes, esters, and fusel oils.

Next comes the hearts, the high-proof alcohol base. Distillers mix the hearts with small quantities of heads, and the blend is diluted and aged to make spirits. With too high a percentage of congeners, the drink tastes rough; with too little, it's bland. The last bit, the tails, is a low-proof mix often set aside and redistilled later.

7 Aging Barrels

The clear liquid emerging from the still is called

moonshine, white dog, or white lightning. It is colorless and harsh. But after a few years in oak barrels, it takes on color, richness, and complexity of flavor. Bourbon whiskey is aged in new but charred oak barrels. Scotch whiskey resides in old bourbon barrels, and Irish whiskey ages in used sherry casks. Gin, ideal for impatient distillers, takes on its character once the white dog is redistilled with a botanical blend stirred into the pot.



cals and grains. While a tinkerer like Potter experiments with his equipment and ingredients, he can modify the flavors of a given batch by including different cuts, or percentages, of the early and late parts in a distilling run. Known in distillery lingo as heads and tails, these parts of the distillate bookend the hearts part of the run. A distiller bottles the product in each of the three phases, then blends all of them together. The heads and tails contain some undrinkable compounds—some distillers use heads to sanitize equipment. But they make up a critical fraction of a spirit's overall profile, adding in characteristic flavors, rough edges, and

heat. Adjusting ratios of each cut allows the artisan to make unique, rich-flavored batches of booze.

But so much of the outcome depends on making these minute adjustments to perfect the procedure. Opening a steam valve another quarter-turn to alter the heat in the gurgling



Watery reflux rains on a stack of copper plates in the NYDC still's column. The purest ethanol vapor escapes the column (right) to enter the condenser (left), then emerges as moonshine. A toast—to fractional distillation!



Lavender

Orrisroot

Cocoa Nibs

Angelica Root

Juniper Berries

Coriander Seed

GIN BOTANICALS

The Main Ingredients

Two spirits dominate American craft stills: gin, which can be perfected quickly, and bourbon. "Every distiller wants a bourbon," Potter says.

GIN London dry gin typically originates with a fermented mash of barley and/or corn, water, and a mix of botanicals. Brooklyn Gin uses the six types seen in the jars on the left. First, the product is placed in steel-column stills for one or two distillations. The ethanol produced is then redistilled with the flavoring agents, which can include dried juniper berries, anise, angelica root, cinnamon, orange peel, coriander, and cassia bark. Last, water dilutes the liquor to between 37 and 57 percent ABV.

BOURBON Bourbon is a pure grain alcohol derived from a fermented mash of at least 51 percent corn, combined with barley malt, rye, and wheat. The mash is distilled two or three times to produce clear alcohol between 50 and 57.5 percent ABV. The liquid is aged for at least two years in charred, white oak barrels. As seasons change, the alcohol seeps in and out of the oak's pores, gaining flavor from the wood.

Mash Masters

Five U.S. craft distillers show the diverse tastes and techniques of a thriving spirits subculture.



Prichard's
Distillery
Kelso, Tenn.

Most rum is made from blackstrap molasses—the sludge left after sugar is refined. Prichard's makes its rums from table-grade molasses sweet enough to sop up with a biscuit.

Maine
Distilleries
Freeport, Maine

The fresh water used to make this still's Cold River Vodka flows past potato fields and filters through miles of underground granite, then arrives pure at the local aquifer.

45th Parallel
Distillery
New Richmond, Wis.

Distiller Paul Werni drives his truck a few miles to pick up corn from a local family farm, then uses it to distill vodka and gin in a still midway between the equator and the north pole.

Peach Street
Distillers
Palisade, Colo.

After years of trial and error, distiller Davy Lindig perfected his torpedo, a charcoal-packed pipe he uses in a 48-hour process to filter Olathe-corn-based Goat Artisan Vodka.

Clear Creek
Distillery
Portland, Ore.

Steve McCarthy's distillery, one of more than 40 in Oregon, is also a pioneer. For 26 years, it has used local fruit and classic European methods to make brandy, eau de vie, and grappa.

pot, fussing with the water-flow rate to compensate for temperatures on tap at different times of the year—all of these techniques factor in. Even master distillers tweak the machines to keep the quality up to par. For rookies like Potter and Katz at the NYDC, experimentation is a way of life.

Later in the hearts run in the NYDC's premier batch, something goes wrong. The neutral grain spirits are flowing at 20 liters an hour. But somewhere along the way, as a few grimacing testers discover, the drink picked up a plastic overtone. Bill Potter, Tom's son and a junior partner in the still, takes a test tipple and spits the mouthful onto the concrete floor. Haase, the technician, suspects that the culprit could be a 400-liter plastic storage barrel. The crew discusses switching to all-metal bins. Tom Potter picks up the test cup, smells its contents, and takes a sip. He frowns, bulges his cheeks, and looks wide-eyed around the open room for

a suitable spot to expectorate. "I just put it right there, Dad," Bill says, pointing to the splatter on the floor. Tom dispatches his mouthful with a pained groan.

The crew will keep tinkering with the formula until they balance the recipe, ingredients, and nuances of operating the new machines. They realize that, as for many craftsmen, one of their most important production methods may just be patience. **PM**

64°46'S, 64°03'W

THE PEOPLE WHO LIVE AND WORK AT ANTARCTICA'S PALMER STATION OCCUPY A VERY SPECIAL COORDINATE: IT'S STAGGERINGLY BEAUTIFUL. IT'S ALSO CHANGING MORE RAPIDLY THAN ALMOST ANY PLACE ON EARTH.

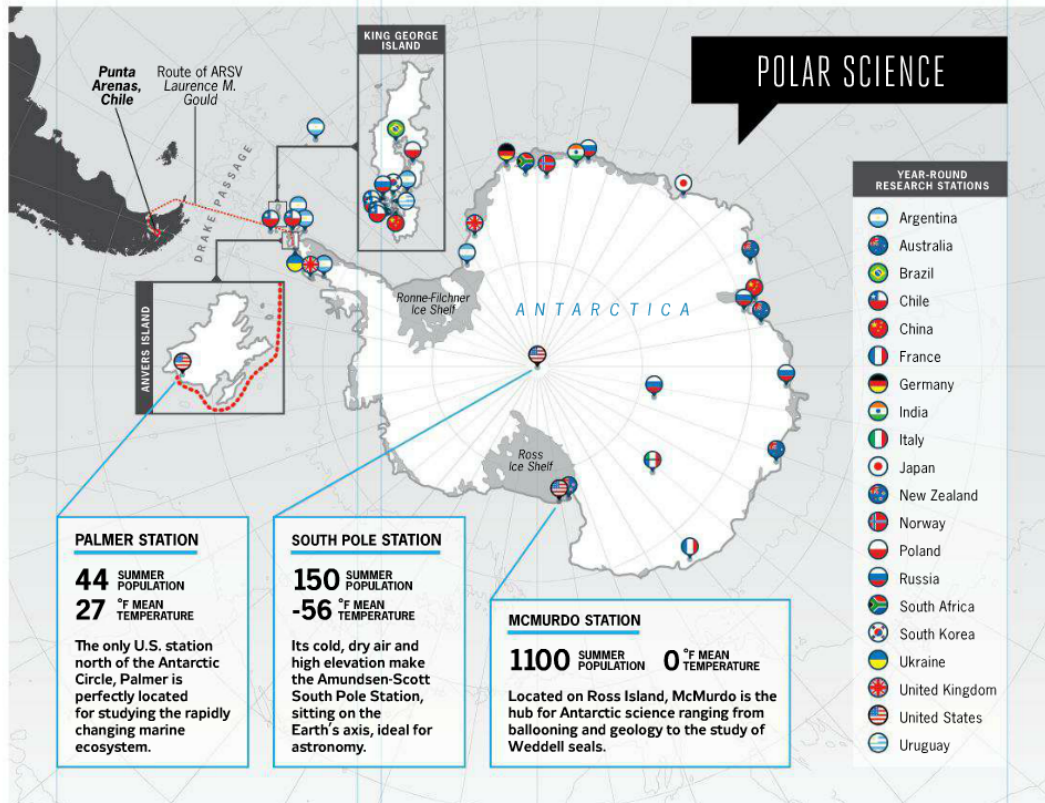
text and photographs by Jennifer Bogo

THE GERLACHE STRAIT LOOKS EXACTLY AS I IMAGINED ANTARCTICA WOULD: Snow spills to the edge of the passage from the jagged landscape lining either side. The tops of icebergs rise from the flat, dark water like stiff peaks of beaten egg whites; the ice just beneath the surface glows turquoise. The air hangs soft and gray, and by the time the ARSV *Laurence M. Gould* rounds the southern tip of Anvers Island and enters Arthur Harbour, a light snow is falling.

Through the thick flakes, a handful of Monopoly-size buildings materialize. Figures in bright orange suits amble to the edge of the dock as the ship pulls in. Some grab the research vessel's towlines; others spot the first snowball flying at the exact moment I do. It comes from the stern, where marine biologist Kim Bernard has dipped into a cardboard-box arsenal. The other side quickly retaliates, and soon the residents of Palmer Station—both current and incoming—are locked in battle.

Palmer is the smallest of the three year-round U.S. research stations in Antarctica and the only one on the West Antarctic Peninsula. It's also the only station without an airstrip. Reaching Palmer requires a four-day voyage from Punta Arenas, Chile, on the *Gould*. The vessel plunges





The Antarctic Treaty, enacted in 1961 and eventually signed by 48 nations, designates Antarctica for peaceful and scientific purposes only. As a result, there are dozens of year-round research stations scattered like sprinkles across its frosted surface. Above: Field biologist Marc Travers counts Adélie penguins in a tiny colony near Palmer Station. Adélies are a true polar species, dependent on winter sea ice that provides critical habitat for their prey. As sea ice has declined, populations of Adélies in the northern West Antarctic Peninsula have fallen 90 percent in the past 30 years.

south through the Drake Passage as the Antarctic Circumpolar Current, the largest current in the world, sweeps through the same narrow channel barreling east.

Just before I left the United States for Chile, Hugh Ducklow, the director of a long-term ecological research project at Palmer, told me that the station's location, chosen in 1965 for its convenience, turned out to be a stroke of great scientific luck. "For decades, nobody had any idea about climate change," he said. "Now we find ourselves at the very spot where it's happening most rapidly."

Over the past 50 years, the average air temperature increased 6 degrees Fahrenheit along the West Antarctic Peninsula, unlike that farther north or south. Scientists have also documented stronger surface winds, cloudier skies, more snowfall, less ice, and warmer ocean water—all adding up to profound changes in the polar ecosystem. Because that ecosystem is relatively uncomplicated, scientists can detect and establish the significance of these changes more easily than,

say, in a coral reef or even in a forest in the U.S. By studying climate change at Palmer, Ducklow says, "we can figure out rules of ecosystem response elsewhere."

Thanks to a fellowship from Woods Hole Marine Biological Laboratory, I've come to document something too: station life. I begin my research in the galley with a penguin-shaped sugar cookie, then go on a tour. It doesn't take long. Pretty much everything is located in two buildings sandwiched between a glacier and the Southern Ocean. A lone street sign points toward Denver (7555 miles) and the South Pole (1744 miles). Three weeks here, I think, could go by very slowly. Instead, they fly far too fast.

"MAN OVERBOARD!" Katharine Coles is pointing at me from a rubber zodiac as I bob in the 32-degree Fahrenheit polar waters. I'm wearing an extra-large neoprene survival suit, which, because I'm only five foot six, bunches in giant folds around my limbs. I feel surprisingly, pleasingly, warm. Lily Glass, Palmer's boating coordinator, tells Coles to drive away from me; I awkwardly swim to a chunk of ice and cling to it for dramatic effect. Then Glass talks Coles through a Williamson turn, a rescue maneuver that brings the zodiac back to the point where I "fell" out.

Glass grew up on the water, pulling lobster pots in New England, and learned her way around an engine after buying a 1971 Volkswagen bus. But mostly it's her unruffled calm, honed while teaching high school science in Massachusetts and Mongolia, that she brings to Boating II—a mandatory class for anyone who wants to pilot a zodiac onto the Southern Ocean. At Palmer, that's pretty much everyone.

"Some of my favorite days are the crappiest out on the water because you have to be that much more focused," Glass says. "And it's those days that really make you appreciate weekends, when you can turn off the engine and not go anywhere." On a Sunday with exceptionally clear blue skies, people pile into zodiacs to chase reports of breaching humpback whales. Coles—who is Utah's poet laureate and, like me,

applied for a grant to visit Palmer—doesn't have to go searching for wildlife. Twice a penguin jumps in a zodiac with her.

DURING THE AUSTRAL SUMMER, which stretches from roughly November to February, there is no real darkness in Antarctica, just twilight. The sun is still shining brightly at 9:30 on my first Friday night. Behind the BioLab, graduate students are setting up an ocean-acidification experiment in a marine tank; in the tank next to that, six people are soaking in the station hot tub. The sound of Cake floats over from the Terra Lab, where an array of instruments constantly monitors seismic activity, atmospheric radionuclides, and electromagnetic waves generated by lightning strikes around the globe. Brian Nelson, the lab's technician, is leading another suite of instruments in a "Terra Jam": Palmer's band is practicing for open-mike night.

ALICE ALPERT SITS on the edge of Bruiser, the wooden work platform mounted across the zodiac, and dangles her brown XtraTuf boots over the water. Alpert's flotation jacket easily doubles her small size. Despite clumsy insulated rubber gloves, she adroitly cocks the latex band on a gray plastic Niskin bottle so that both ends remain open, and lowers it with a winch 10 meters into the Southern Ocean. Then she fires a weight down the line to snap the ends shut, capturing water.

Researchers have been methodically sampling the ocean here for the past 20 years, and the data reveals changes at the very bottom of the marine food web. As stronger winds churn the water column, for example, phytoplankton are pushed deeper, away from sunlight, so they bloom far less often. These winds also upwell

deep, carbon-dioxide-rich water, limiting the amount of CO₂ the ocean can absorb from the atmosphere—a process Alpert's team is trying to understand.

I'm tasked with operating the winch to bring the Niskin bottle to the surface. Only, distracted by the line coiling at my feet, I look away at exactly the wrong moment and the bottle hits the top of the winch with a thud. I click the button to try to lower it. No power. The team takes it in stride, heading back to exchange Bruiser for Wonderbread, which has a hand-cranked winch. Later, someone gives me the blown fuse as a souvenir, saying: "Welcome to science."

THE SOUTHERN OCEAN can be glassy and smooth or whipped by 50-knot winds and roiling with giant swells. Because these conditions change within minutes, safety at Palmer is taken very seriously. Whenever a group of boaters signs out a zodiac, they give themselves a name, which may or may not reflect the purpose of their trip. Like Moe at his

tavern on *The Simpsons*, a communications officer dutifully repeats this name over the two-way radio every time crews check in—which is often. During my stay at Palmer, names included Going Viral, Bromance, Sir Ernest Shackleton, Apollo 25, and Hold My Beer and Watch This.

SLEEK AND YELLOW, the Slocum Glider autonomous underwater vehicle resembles a torpedo. When I peer inside, it looks much less ominous. Rows of D batteries line the aft end, and I can see all the way through to a buoyancy pump. The glider is propped up on a counter in the lab while Travis Miles, a graduate student at Rutgers University, dismantles it. He's trying to figure out why the leak-detect sensor went off when the team deployed the vehicle. "Being down here has been a whole new world of beta testing," he says.

Once the problem is fixed, the team plans to send the glider across a deep-sea canyon near Palmer. Such canyons allow warm, salty water at the bottom of the Antarctic Circumpolar Current to flow up onto the continental shelf. Historically, that's been a boon to marine life, delivering heat and nutrients that stimulate food supplies. Only now they appear to be delivering way too much.

The real engine of the Antarctic ecosystem is the Southern Ocean: Water holds a thousand times more heat per unit volume than air does. Over the past 50 years, water along the peninsula has warmed significantly. Ice transfers this heat to the atmosphere: The midwinter air temperature has risen 11 degrees Fahrenheit, five times the average global increase. The winter ice season has lost 83 days, effectively disappearing.

The gliders, scientists hope, will track how greater volumes of this warm, deep water are being swept onto the shelf. Unlike humans, who are limited by weather and their own endurance, gliders can slalom through the Southern Ocean day and night for hundreds of miles. They move by changing buoyancy: pulling a coffee cup's worth of water into the nose, then pushing it back out again.

Miles shows me the air bladder in the glider's tail, a balloon about the size of an airplane pillow. When it inflates, the tail lifts out of the water so an iridium phone can call Rutgers for the glider's next set of instructions. "If we see something interesting," he says, "we can adapt how we fly the glider and hypothesize as we go."

"BIRDERS, THIS IS DRAGNET." Silence ensues. Alex Culley, a researcher from the University of Hawaii at Manoa, tries again. He's in a zodiac, sampling for marine viruses. There are a billion in every liter of seawater, and he's trying to tease out their role in the polar ecosystem. Another long pause, then Glass radios from the station: "Dragnet, this is Lily. They have to hike up a hill in order to get reception."

"Thanks, Lily. Actually, maybe you can answer this. We've got a chinstrap [penguin] that's jumped onto our boat. Please advise."

Palmer Station residents name especially large icebergs after famous "bergs." Below: A wave crashes against Mark Wall-berg, which blew in the previous summer. Near right: Kim Bernard and Carolina Funkey hoist a net from the water while towing for zooplankton. Far right: Rutgers researchers Kaycee Coleman and Mike Garzio prepare to launch a Slocum Glider.



Construction-cone orange. If there's an official color for Palmer Station fashion, that would be it. I quickly trade my electrically heated Columbia parka for an insulated Mustang suit—extra bright should the man-overboard drill be genuine, and with the safety bonus of not mixing LED batteries with salt water. I pull a fleece neck gaiter up over my chin and a wool hat down over my ears. My fingers seem to get cold and wet no matter what I do.

KIM BERNARD and Carolina Funkey, researchers from the Virginia Institute of Marine Science, work quickly in the back of the zodiac. Bernard holds the rope attached to a tow net taut while Funkey ties a knot with the slack. I throw three buoys over the side and radio Palmer with our next destination.

"Psycho Killers headed to Station E. Copy," the comms officer radios back. Bernard pushes the throttle forward.

As our name implies, we're fishing for krill, shrimplike crustaceans that are the favored food of everything from penguins to whales and some types of seals. Over the past several years, catching krill has gotten tougher. On our first pass, we net only five. "Antarctic krill rely very heavily on sea ice for their life cycle," Bernard says in a lilting South African accent, which she also uses to great effect in the station band. "Because the sea ice is declining, they have less and less area where they can survive."

Krill also depend on phytoplankton, but they're not good at grazing the small cells that now dominate the algal community. Other zooplankton are. "One thing that's ringing all the alarm bells is the fact that salps are moving in and taking over," Bernard says. Like creatures from a bad B movie, salps pulse through the water column, trapping food in a mucous mesh. They're voracious eaters, but of little nutritional value themselves. If they run into a phytoplankton bloom, they just eat until they die.

PENGUINS ARE ENGINEERS. Each spring, they meticulously build nests of rock—some comically high—then take turns lying atop them for weeks. I didn't fully appreciate this until I stepped out of a zodiac onto Torgersen Island with the Birders—the only group that never changes its name. The three Birders weave among colonies of Adélie penguins, careful to steer clear of the occasional elephant seal.

Unlike the other scientists, the Birders work outside Palmer's main lab building in a faded red tent stuffed with Clif Bars and yellow weatherproof notebooks. When they arrive at study sites, on islands near Anvers, they strip off their orange Mustang suits to reveal head-to-toe khaki. After stripping off my own Mustang suit to reveal more neon orange, I learn why: Khaki doesn't scare the birds.

SKUAS ARE CRAFTY. I watch one of the large brown birds saunter up to an Adélie penguin colony. It has a nonchalant air, but the penguins know better. They extend their necks, swinging their heads from side to side for a better look, and chatter

angrily. Stock still, the skua waits them out. One of the penguins shifts on its rock nest a little too far and the skua's mate swoops in for its egg.

I'm appalled. It's like seeing a character from *Happy Feet* picked off. "They're predators, so they get a bad rep," says Jen Blum, a field biologist at Palmer for her sixth season. "I love that they're ballsy." But in the real-life skuas-versus-penguins plot, neither are thriving.

Adélies are hard-wired to return to the same exact spot to breed, at the same exact time, year after year—regardless of krill supplies or spring snowstorms that flood their nests. In the 1970s there were 15,000 breeding pairs on the islands surrounding Palmer; now there are fewer than 3000. "The skuas are following the same trend as the penguins," Blum says.

The Birders census skuas, too, and as Blum measures an egg, the bird's mate dive-bombs her, wings outstretched like a B-57. It lands on her back, then moves up to her head, where it tries to pull off her hood with its beak. Blum is unperturbed: "That's why I wear a hood."

DANGER CREVASSES STOP! The sign at the top of Marr Glacier is surrounded by ominous black flags. Roped hip to hip,

(CONTINUED ON PAGE 95)



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DIY

Tech

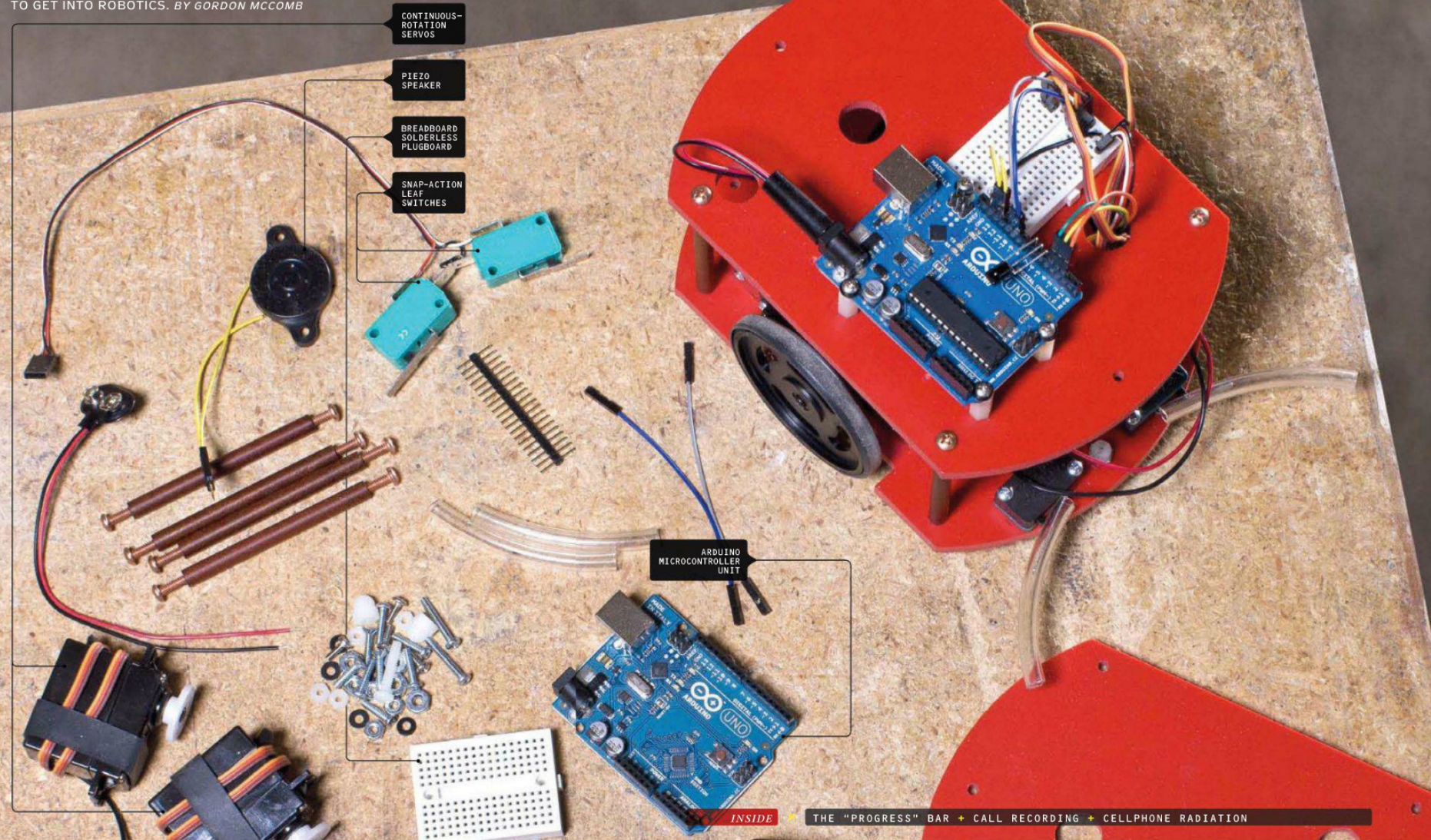
➔ I wanted to start building robots the moment I saw the sci-fi movie classic *The Day the Earth Stood Still* (the original, mind you, not the remake). My initial attempt, shortly thereafter, was cobbled together from nothing more than random TV parts and scrap wire I had scrounged from my dad's electronics junk box. The machine didn't really do anything—other than get me into trouble. My father informed me that those “random” parts were actually rather pricey RCA picture tubes.

Still, it was my first robot, and your first robot is one you never forget. Watching your creation do something as simple as scoot around the floor is exhilarating, particularly if you've built it from scratch.

Companies such as Lego and Vex offer inexpensive prefab robotics kits aimed at children and educators, but you'll get far more flexibility in the long run by learning to build a true, circuits-to-servos DIY robot. Plus, it has never been cheaper or easier to put one together, and the result of your efforts will greatly exceed what was possible even five years ago. (Trust me, I've been at it for over 20 years.) Best of all, robot building offers something

Build Your First Robot

AFFORDABLE PARTS AND SIMPLE COMPUTING MEAN THERE'S NEVER BEEN A BETTER TIME TO GET INTO ROBOTICS. BY GORDON MCCOMB



Our completed computer-controlled robot can sense and avoid obstacles without user input. Download plans at popularmechanics.com/byfr.

that's increasingly rare in the world of electronics: the opportunity to create a moving, working machine with your bare hands. I've worked with POPULAR MECHANICS to design a robot project that anyone with a bit of technical skill can complete, even if you've never built a bot before. It's affordable, readily expandable, and a great deal of fun.

Defining the Bot

➔ **Our double-decker** beginner bot uses a miniature computerized brain to move across the floor, mindful of nearby obstacles. If it (gently) hits something or someone, the robot emits an apologetic tune, backs up, and sets off in a new direction. In terms of basic behavior, it's a bit like a Roomba self-driving vacuum cleaner. To DIY roboticists, this style of machine is known as a roving bot.

We've also designed the robot to work with almost any universal remote control, so you can manually command your robot to stop, start, and turn. We've tried to keep it to a reasonable ambition level: It should take 2 hours or less to construct, and it doesn't require special tools. There's no circuit assembly, and only basic soldering is needed.

At the heart of our bot is a \$30 Arduino microcontroller board that's small enough to be powered by a 9-volt bat-

tery. This microcontroller serves as a small programmable computer that connects software to actual, real-world functions. Programs, or sketches (in Arduino-speak), tell the microcontroller what to do. You use a personal computer to create sketches, then those sketches are uploaded via USB cable to the internal memory of the microcontroller. Sketches can do things like run motors or monitor the state of switches and sensors.

We chose the Arduino microcontroller because it is designed specifically for DIY projects like ours, and because it's open-source, meaning that its hardware and software designs are open for modification and free of licensing fees. Since it lowers the entry barrier to robotics in virtually every sense, from cost to difficulty, the Arduino is becoming something of a superstar in the world of bot builders.

Software for programming the microcontroller is free to download from the official Arduino site and is relatively easy to use, because it was designed not just with programmers in mind. It runs on both PCs and Macs and includes intuitive tools that allow bot-builders to download and install ready-made programs. The vibrant community of Arduino users has even designed super-simple, graphical-software-design apps, such as Modkit and Minibloq. These ease the learning curve not just for Arduino, but for basic programming in general.

The Arduino gets wired to your robot's hardware through a breadboard. Also known as a plugboard, this device routes electronic signals from one part of the robot to another. Breadboards make it easy to wire everything quickly and reconfigure your connections on the fly without hard-soldering everything together. It's a sort of switchboard for your robot's servos, sensors, switches, and processor. If the Arduino is the bot's brain, this is its nervous system.

Our bot uses two gear motors for propulsion, with a free-rotating caster out front. These motors are specialized versions of radio-control servos typically used for model airplanes. Instead of rotating just a few degrees, they keep turning. This type of motor—the continuous-rotation servo—is both low-cost and easily screw-mountable. The servos live on the bottom of two decks, which are separated by risers. The twin-deck design leaves ample room for mounting electronics.

Building the Bot

➔ **Our parts list** is modest—that way we could keep costs down and make our

project simple. But you're probably not going to find most of the bits and pieces at your local electronics store. Most bot-builders do their shopping online at sites such as SparkFun, RadioShack, and Adafruit. Our build had just under 20 parts, excluding screws, bolts, and wires. We've published full, step-by-step instructions online at popularmechanics.com/byfr, along with a complete parts and purchasing guide and preprogrammed, downloadable Arduino sketches. There's plenty of flexibility when it comes to the body material and shape—our plans use PVC sheet plastic, but almost any lightweight, ¼-inch-thick material will do, so feel free to



BILL OF GOODS
 WHAT'S IN A ROBOT, ANYWAY?

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VARIOUS HARDWARE:	\$7.50
ARDUINO SOFTWARE:	FREE

TOTAL BUILD COST

\$95

-

\$112



NEXT STEPS

BUILD YOUR SECOND ROBOT

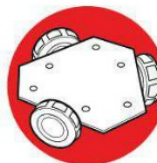
So you've built, rebuilt, programmed, and modified your first robot. Chances are it won't be your last. Here are three next-level DIY robotics projects.

TRACK BOT



A track-driven robot is a fantastic followup project in terms of both difficulty and utility. This can be constructed with as few as two drive motors, carry heavier loads than a caster robot, and, most importantly, handle off-road (or, rather, off-floor) operations on dirt, grass, snow, or carpet.

HOLONOMIC BOT



Holonomic bots, a type of omnidirectional bot, use a trio of specially designed wheels, each with its own set of tiny casters, to move in all directions. They are especially well-suited to camera-centric projects—these guys can turn on the spot, move laterally, or rotate in place.

WALKING BOT



Walking robots are an order of magnitude more complex than wheel- or track-based bots, but they're not beyond the reach of a garage tinkerer. Build difficulty varies, depending on the number of legs and joints, but the payoff is huge: Whether it's got eight legs or two, a walking machine is a robot in the purest sense.

modify the platform design.

With a two-level robot, you'll want to start at the bottom and work your way up. The lower deck of our bot holds the two battery packs and all of the mechanical bits and pieces. A dedicated AA-battery pack for the servos is fixed to the top of the deck with adhesive Velcro strips for easy removal. The servos that turn the wheels are locked down with machine screws, plastic mounts, and L-brackets. The whisker switches are thin leaf springs bolted to the front of the bot, each encased in aluminum tubing for protection.

The top deck is home to the Arduino microcontroller, as well as the speaker and the breadboard. The Arduino sits on a bolt-on mount; the speaker, the breadboard, and the battery case are mounted with double-sided tape.

The two levels of the deck are connected by four thin deck risers. Once the decks are screwed into place, the rest of the build is a matter of wiring: Connect 22-gauge wires from the servo, the switches, the infrared receiver, and the speaker to the breadboard, then connect the breadboard to the Arduino.

Operating the Bot

➔ **Now comes your Dr. Frankenstein moment:** testing the robot for signs of life. Directly connect the 9-volt battery to the Arduino, then link the AA-battery pack to the breadboard. Connect the Arduino to a PC or Mac via a USB cable and open the Arduino app on your computer. If you were writing your software from scratch, this is the point at which you'd sit down and do some programming. You can experiment,

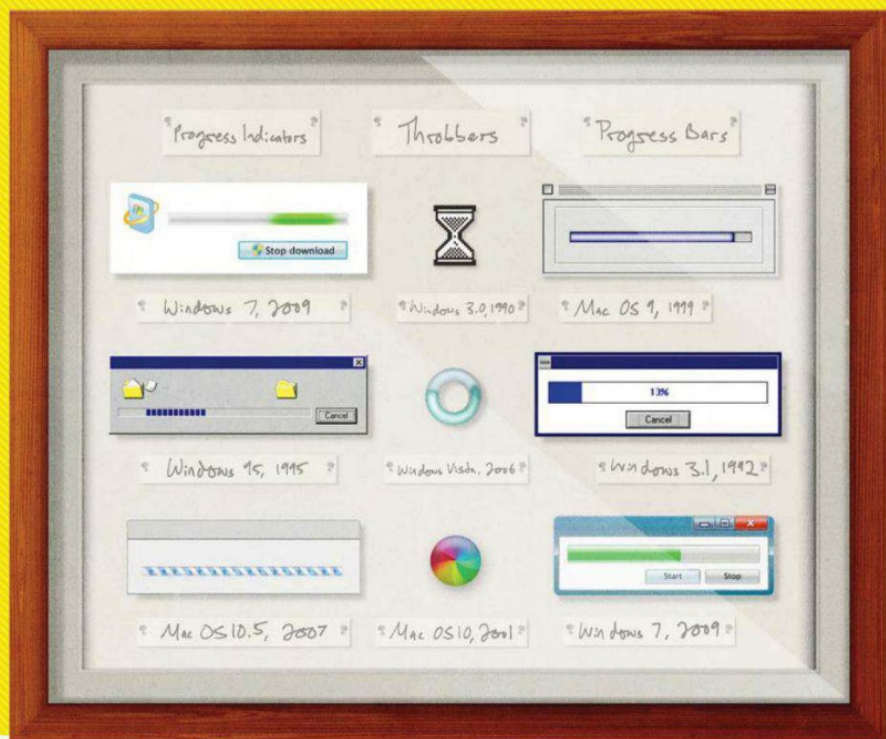
but to get you started we've supplied a full-featured sketch, downloadable from our website. Still, if you use our code, examine it in the Arduino app and you'll start to pick up on the basic logic pretty quickly. (For a much simpler sketch, take a look at the LED-flashing Blink program included with the Arduino software.) When you're ready to test a sketch, connect your robot to your computer via USB and click the Upload button. This will install the software, and should bring the robot to life.

As designed, our robot has three core capabilities: It can be driven with a universal remote control, it automatically senses when it hits an obstruction, and it backs itself out of trouble. But the truly great thing about a roving robot is that it's easy to modify and expand its behaviors. Our robot can take on new missions with simple programming and hardware changes—there are countless tutorials for basic Arduino programming online.

Don't be afraid to try new things, or to dive right into the code of a sketch and start mucking around with variables. If something doesn't work or doesn't behave as you want it to, just reload the demo program we've supplied and start again. In addition, robotics hobbyist sites such as SparkFun and Adafruit offer a multitude of hardware add-ons for Arduino bots. Adding infrared sensors can enable basic object identification or collision avoidance. You can even install a small camera to record stills or video from a bot's-eye view. These upgrades are neither expensive nor complicated.

Robots are ideal entertainers. I took a prototype of our project to my father's 91st birthday party—five generations of my family were all engrossed in some red plastic scooting across the floor. Even my dad enjoyed it, though he couldn't help himself when he asked, "So, where are the vacuum tubes?" **PM**

Gordon McComb is the author of Robot Builder's Bonanza. Find it online at robotoid.com.



Digital Clinic

by John Herrman

Q An Astonishing Lack of Progress

Every time I download or install a file, I get a progress bar that gives me no indication of how long the process will take. Why can't anyone make these things accurate?

A A progress bar is never a good sign. It means that your computer is held up and that you're in for a wait. The frustration of waiting for a process to complete itself is compounded by another unfortunate fact: The progress bar is essentially lying to you. More often than not, your computer has no idea how long the process will take—hitting the 50 percent mark might mean you're halfway done, or it could just as well mean that you've barely gotten started.

Probably the most common progress indicator is the file download bar found in Web browsers. Download time should be easy to predict: All a computer needs to do is divide the total file

ILLUSTRATION BY RADIO

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DIY Tech DIGITAL CLINIC Q+A

size by the measure rate of download. But download speed is unpredictable, subject to the ebbs and flows of your connection, the busyness of the file's server, and the performance of your router.

The progress bar for an application installer, or setup file, is an order of magnitude more complicated than a download-progress bar. It must track hundreds of different operations, each of which is dependent on external factors such as computer speed, Internet connectivity, and user activity. Brad Myers, a professor at Carnegie Mellon's Human-Computer Interaction Institute, puts it thus: "There are many areas of computing where the system as a whole cannot predict how long [a task] will take, so progress bars don't move in a consistent way." Estimating how long it will take to install something as complex as a computer game borders on guesswork.

The result? App developers don't always bother to make their progress bars accurate. Instead, they use freely available off-the-shelf progress-bar code that tracks how many raw operations have been completed, granting no special weight to those that may take longer than others. In some situations, developers give up entirely on traditional, determinate progress bars, resorting to indeterminate progress bars, or throbbers, in user-interface parlance. These indicators look and move in ways that suggest progress—think spinning pinwheels—but really just repeat until the task is complete.

Chris Harrison, a Ph.D. candidate at Carnegie Mellon, is attacking the problem of the progress bar from an unusual angle. Using principles from the nascent field of psychology called time design, he has figured out a way to make a progress bar *feel* like it's moving faster than it actually is. After testing different movement patterns—linear, surging, fast-then-slow—along with different animations, Harrison arrived at the fastest-feeling, albeit fundamentally dishonest, progress bar: one



BETA TESTER

WANNA TRY WINDOWS 8?

Start Microsoft's next major update to Windows, due late 2012, will include an all-new Metro interface. Here's how to install it for free (msdn.microsoft.com).

Download the Windows 8 developer preview.

1

Burn it to a blank DVD using the Windows disc image utility.

2

On your test PC, set your optical drive as the boot drive. Insert DVD; restart.

3



When the Windows 8 menu appears, select Install Now. To install alongside Windows 7, click on Custom and select an empty partition or drive. If not, just follow the onscreen installation prompts.

4

After reboot, you'll see the new Metro interface. Welcome to Windows 8.

5

that speeds up as it progresses, and contains a backward-moving ripple animation.

Alas, the progress bar is a necessary evil. "Unfortunately, there will always be computer programs that cannot be executed instantaneously," wrote Myers in his bizarrely engrossing 1985 paper, "The Importance of Percent-Done Progress Indicators for Computer-Human Interfaces." Today, that statement holds true: "As long as there have been computers, there have been computers that don't run fast enough," Myers tells PM. "When there's more computer power available, there's more desire to use it." He adds: "[Progress bars] would stop only if human progress stops." I can't quite tell if this is an optimistic view of the future or an incredibly depressing one, but I suspect it's right.

Cancer Concern 🔴 I see a different headline every week, so set me straight: Do cellphones cause cancer or not?

At this point, there is no compelling evidence to suggest they do. The closest thing to a definitive study on the subject was recently published in the medical journal *BMJ*. It examined the incidence of brain and nervous system cancer in 358,403 Danish cellphone users over 10 years and found no meaningful link between cellphone use and tumor growth. So call and text and browse without fear—for now.

This Call Is Being Recorded 🔴 Is there an easy way to record cellphone calls? It would make keeping track of my sales calls a lot easier.

The reason call recording isn't considered a standard cellphone feature is a good one: California, Pennsylvania, and nine other states prohibit the recording of phone calls without the consent of all parties. So first, read up on your local laws—the Reporters

Committee for Freedom of the Press maintains a list of state rules on its website. Smartphone users can try call-recording apps—Record My Call for Android, Google Voice for iPhone—but I've found the former unreliable, and the latter works only with outgoing calls. The best option for any cellphone is a hardware voice recorder. Phone mics, such as the Olympus TP-7, retail for \$20 or less, sit between your ear and your handset, and connect to any external recording device with a microphone jack—including many MP3 players. It's not the most elegant solution, but it'll always work.

Power Drains 🔴 I know desktop computers, game consoles, and cable boxes can inflate your power bill, but what about the little gadgets? I charge my phone every night.

Modern smartphones' daily charging cycle and ever-nagging battery indicators imply heavy power use. Fortunately, the numbers tell a different story.

A typical smartphone uses about 5 watts of electricity while charging; when the device is plugged in but fully charged, that number drops close to zero. A lithium-ion smartphone battery will take roughly 4 hours to reach a 100 percent charge from empty. Assuming that the phone requires a full recharge every day—most do not—and using the national average electricity price of \$0.12 per kilowatt-hour, a smartphone will consume about \$0.07 of electricity per month. That's \$1.68 over the course of a two-year contract.

In other words, it's probably not worth fretting over. Ditto for your tablet, camera, MP3 player, or camcorder. Even your hungriest gadgets use a tiny fraction of the electricity required by your a/c, heater, or dishwasher. **PM**

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All the Buzz

WE TEST 11 PORTABLE TABLE SAWS TO FIND THE CLEANEST CUTTER. BY ROY BERENDSOHN

➤ The table saw is the beating, buzzing heart of the wood shop. It rips, crosscuts, and miters, enabling a build as simple as a toolbox or as complex as a boat. Likewise, for home remodeling, the table saw cuts trim pieces (simple) and helps in constructing extension jambs to fit windows in thick, energy-efficient walls (complex). The new breed of table saw is tougher, more capable, and more accurate than older models, with expanding tables, sliding supports, improved rip fences, rolling stands, and 10-inch blades driven by 15-amp motors. We tested almost a dozen brands, cutting 2x lumber, plywood, and oak. Here's what we found.

INSIDE ✕ ROOF SNOW LOADS + REC-ROOM RACK + THIN OAK FLOORING

PHOTOGRAPH BY DOUG ADESKO

BEST SMALL SAW



Rating

BOSCH
4100DG-09

Weight (with rolling stand):
113 pounds
No-load rpm:
3650
Max rip, right of blade:
25 inches
Price:
\$760

Likes: Superbly designed and detailed, the Bosch proved to be the test's most sophisticated saw,

complete with a digital readout on the fence and a stable, rolling stand. The saw has cutting power to spare and dead-on accuracy in ripping, beveling, and cross-cutting. The large, well-positioned handle for the sliding-table lock made the tool very user-friendly. It was also the only saw in the test with an arbor-lock button, a feature so handy it ought to be an industry standard, in our humble opinion. **Dislikes:** Unlocking the table causes a pop-up tab to rise above the cutting surface. You can easily hit the tab when sliding the fence.

CRAFTSMAN
315.218291

Weight (with rolling stand):
126 pounds
No-load rpm:
4800
Max rip, right of blade:
33 inches
Price:
\$530

Likes: The Craftsman is a solid, accurate, and powerful cutting machine. Based on the design of the

Ryobi BT3000, it picks up where that well-regarded saw left off, featuring a larger motor (15 amps versus 13) and a substantial rolling stand. The construction exhibits good fit and finish throughout. **Dislikes:** We discovered a design flaw that we believe poses a danger to users, so we failed this saw. The sidebar below describes the problem and gives Craftsman's response to our discovery.

DEWALT
DW745

Weight (without stand):
45 pounds
No-load rpm:
3850
Max rip, right of blade:
17 1/4 inches
Price:
\$400

Likes: We fished the DeWalt out of the box, plunked it down on a workbench, and ripped a straight

and smooth edge on a piece of 3/4-inch oak. The saw's rack-and-pinion fence facilitated that accuracy; rather than sliding in tracks, it rides in a toothed rack controlled by a pair of gears. Small though the saw may be, it cuts with enviable power, thanks to a motor that turns relatively slowly (3850 rpm compared with 4000 to 5000 rpm for other saws) but produces good torque. **Dislikes:** Unlike its big brother, the DW744X, the DW745's small size limits ripping width and eliminates dado cuts.

CRAFTSMAN

A Good Saw With a Lousy Switch

At PM, we test hundreds of products in a variety of settings—garages, basements, farms, and even golf courses. Over the years, we've reviewed many Craftsman tools, with consistently good results. But we feel that the table saw we tested (see above) is dangerously flawed.

While the UL-listed machine can be used in

both sawing and routing modes, it has only one on/off switch. The saw's body has an outlet and two power cords, one full-length and the other a stubby pigtail. Using the saw entails inserting the pigtail into the saw-body outlet and the full-length cord to the power source. To power up the router table, the

user unplugs the pigtail and plugs the router into the outlet on the saw body. (The on/off switch starts the router while the saw remains off.)

However, during our test, when we connected the pigtail to a live extension cord, the saw started and could not be shut off using the on/off switch—a blatantly

dangerous setup.

This is covered in the owner's manual, but it's still a hazard. A Sears rep told PM that a warning sticker would be affixed to the saw, adding: "As a longer-term solution, a design is being developed to ensure the table saw can only be operated within the guidelines of the owner's manual."

—R.B.

DIY Home TABLE-SAW TEST

JET
JBTS-10MJS

Weight (with rolling stand):
105 pounds
No-load rpm:
4000
Max rip, right of blade:
25 inches
Price:
\$694

Likes: Like three other saws in the test (Porter-Cable, Rockwell, and Ryobi), the Jet has a sliding outfeed support. This is especially helpful when you're working on-site: You don't have to jury-rig something to receive long workpieces as you feed them off the table. The saw's other features also seem well-designed for construction-site use. The elevation handwheel has a fast, smooth action, and the flip of a lever unlocks the blade to allow bevel cuts.

Dislikes: The Jet's wheeled stand is handy for moving the saw but not stable enough for truly precise cuts.

MAKITA
2705

Weight (without stand):
65 pounds
No-load rpm:
4800
Max rip, right of blade:
25 inches
Price:
\$960

Likes: At the flip of a switch the Makita spins to life with a smooth hum, making rip after rip without bogging down. The precise controls enable smooth, accurate adjustments of blade height and bevel. Cutting width is firmly established with a hefty, comfortable cam lock on the fence, and not one but two levers secure the sliding table. The riving knife that prevents wood from being pinched by the saw blade easily pivots up and down without tools.

Dislikes: A fussy little Phillips screw anchors the throat plate. Also, the list price is absurdly high; the actual purchase price can be nearly \$400 less.

Light-Duty Table Saws

CENTRAL MACHINERY
97896

Weight (without stand):
33 pounds
No-load rpm:
5000
Max rip, right of blade:
9½ inches
Price:
\$130

Likes: It would be unfair to pit this little saw (or the Skil) against the pro-quality models in the balance of the test. It's small and light enough to carry with one hand, so it scores high marks for portability and space-saving. For instance, suppose you need a saw up at the hunting cabin to repair squirrel damage to the pine trim. Just throw this guy in the trunk and off you go. It'll get the job done.

Dislikes: The blade must be purchased separately, and the blade-guard riving knife is a design that's decades out of date.

SKIL
3310

Weight (without stand):
34 pounds
No-load rpm:
5000
Max rip, right of blade:
10 inches
Price:
\$160

Likes: We're not tool snobs here at PM, and that's why we like this unassuming little saw. It isn't pro quality, but it's got enough power for home projects, and with a little finesse, adjustment, and a steady hand, you can coax cuts out of it that are surprisingly accurate. Again, finesse is the operative word—the 3310 doesn't have the power or precision of the Bosch, Makita, Ridgid, or DeWalt. Still, it does the job nicely.

Dislikes: The safety interlock key is so loose it falls out every chance it gets.

Rating

BEST
OVERALL

PHOTOGRAPHS BY PHILIP FRIEDMAN

Rating

PORTER-CABLE
10-INCH JOBSITE TABLE SAW

Weight (with rolling stand):
74 pounds
No-load rpm:
5000
Max rip, right of blade:
26 inches
Price:
\$300

Likes: We love the simplicity and user-friendliness of this product, right down to the owner's manual, which includes clear, full-page instructions on how to make a pushstick. The machine cuts with reasonable power, and all of its features are intuitive and solid, and they move smoothly. One wheel cranks the blade up and down; another wheel tilts it. A pivoting lever locks the blade bevel. A large handle fixes the fence position, and an outfeed support slides out of the saw's back.

Dislikes: The Porter-Cable, like the Ridgid, has a recessed locking tab that pops up and can interfere with the fence.

RIDGID
R4510

Weight (with rolling stand):
94 pounds
No-load rpm:
4400
Max rip, right of blade:
24½ inches
Price:
\$500

Likes: Mobility is a big plus with this saw. The wheeled stand is a standard feature; it folds and unfolds easily, and the big wheels make moving the saw as easy as rolling a bike along a sidewalk. The Ridgid cuts with formidable power and grace, keeping up with the Bosch and the Makita, the other two big boys in our test.

Dislikes: The locking tab for the sliding extension is recessed into the table, a decade-old design. When raised, the tab obstructs the fence.

ROCKWELL
7241S

Weight (with rolling stand):
74 pounds
No-load rpm:
4800
Max rip, right of blade:
30 inches
Price:
\$400

Likes: Need oversize ripping width? At 30 inches, the Rockwell has you covered. We also like its low-tech but thoughtful features, such as a sawdust bag that hangs below the table, a redline pointer with a large magnifying window that makes it easy to read the scale, and a full 6 inches of table width in front of the blade (topped only by the Craftsman at 7¼ and the Makita at 8¼ inches). Rocky was well-mannered in all other respects. Its blade and fence are easily and accurately adjusted, and it has plenty of cutting power.

Dislikes: The Rockwell uses a novel fold-down extension table (not one that slides out). The basic design is good, but it needs a more substantial folding hinge.

RYOBI
RTS30

Weight (with rolling stand):
56 pounds
No-load rpm:
5000
Max rip, right of blade:
30 inches
Price:
\$250

Likes: Inexpensive, lightweight, and no-frills—that's the Ryobi. If you own a full-size stationary cabinet saw and you're looking to add an inexpensive portable model, this is a good choice (on sale, it costs \$200 or so). It has more than price going for it, though. The Ryobi has a sliding outfeed extension support (like the Jet and the Rockwell), and it cuts with adequate power.

Dislikes: The Ryobi's fence locks securely, but the fence's movement is a bit on the sloppy side. Be careful moving and locking it or you'll introduce inaccuracy.



Homeowners Clinic

By Roy Berendsohn

Q Top-Heavy

Last winter we had snow on the ground that was up to our hips. The drifts on the roof were 5 feet deep. Made me wonder: How much snow is too much for a roof to handle?

A I wish there were a simple answer, but none exists. You *can* look for signs of an overloaded roof, though. I'll explain those in a moment.

But first, to provide perspective, I want to answer the simple question: What is a roof? It's a complex assembly of rafters and related structural members, trusses, the roof deck, and even the roofing material. Whether a roof can sustain a load without damage or collapse depends mainly on the depth and density of the snow, as well as the depth and spacing of the rafters and trusses.

Other factors include the surface slope and texture, and the shape and location of the drift.

The ideal pitched roof is smooth and steep (so the snow slides off), and framed with closely spaced rafters (for strength). It also helps if the roof is in a sheltered area; the snow settles on it evenly, rather than being blown into large drifts (which can cause a roof to fail).

So, a risky roof is flat or slightly pitched, and in a location that is exposed to the wind. Shallow roofs adjacent to or below taller, steeper ones are especially vulnerable to a load of snow sliding down from above. For example, low-sloping roofs over porches, carports, and hastily built

additions (which also often have under-size rafters) can be vulnerable when the snow flies.

Another hidden danger, according to Jeff Geary, a PM Homeowners Clinic contributor and an architect in Staten Island, N.Y., is a roof assembly from which collar ties have been removed. Located about one-third of the way down from the ridge, the supports connect the rafters and counter the spreading effect created by snow loads. "Many times I go into attics and find that homeowners have removed collar ties to get extra headroom, install a bedroom for the kids, or store holiday decorations," Geary says. "Homeowners should know that collar ties are there for a reason."

You know your roof may need bracing if the rafters are cracked from previous heavy snows or if they've been damaged by fire, termites, or rot. Obviously, you'll need to take a look under the hood, so to speak, to find these conditions. Also, if the roof deck appears rotted, that points to a deeper problem. The roofing should be removed and the deck replaced.

If after a heavy snow you go into the attic and see that the rafters are severely bent by the weight of the snow above or if you hear cracking and popping, that's reason to be concerned. Another bad sign: The house's frame has moved enough to jam shut a door at the front or the back of the house. In this case consult a structural engineer about strengthening the roof assembly.

Regardless of your roof's condition, remove drifts using a roof rake with an extension pole, or hire a pro for the job. Take care not to damage flashing or shingles; the goal isn't to clear every flake, but rather to ease the load.

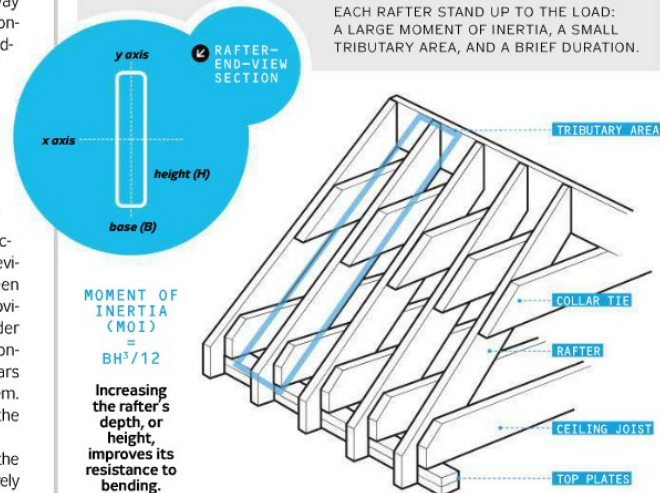
On the Level ➔ I put a fill valve in my toilet tank and asked my neighbor, a plumber, to take a look. After one glance he told me that the valve was seated too low and could pollute my water supply. Is he right? Maybe. Lift the lid and look carefully at



BUILDING BASICS

HOW A ROOF WITHSTANDS SNOW LOADS

FORTUNATELY, THE VAST MAJORITY OF ROOFS DON'T CAVE IN, EVEN WHEN THE WEIGHT OF THE SNOW ON THEM EXCEEDS WHAT THEY'RE DESIGNED TO CARRY. THREE PRIMARY FACTORS HELP EACH RAFTER STAND UP TO THE LOAD: A LARGE MOMENT OF INERTIA, A SMALL TRIBUTARY AREA, AND A BRIEF DURATION.



RAFTER DEPTH AND MOI

Building codes specify that rafters withstand a snow load expressed in pounds per square foot (psf). The higher the psf snow-load requirement, the deeper the rafter must be (or the more closely spaced to its neighbors). A measure of a rafter's bending resistance is its moment of inertia, or its inertial resistance to movement in the form of bending. The typical rafter's MOI is more than enough to handle snow loads.

TRIBUTARY AREA

The roof deck collects the snow load and transfers the weight to the rafters. For any rafter, the portion of the roof deck that transfers this load is the tributary area. It extends outward in both directions from the center of the rafter's thickness midway to the next rafter. Because rafters are typically spaced 16 inches on center, this amounts to 8 inches (in both directions) from the rafter's center line. The smaller the area, the lighter the load each rafter carries.

DURATION

For most roofs, the duration of a snow load is brief. If the roof had to carry a weight equivalent to a snow load all year without weakening, it would have to be much more robustly built. Within a few days of falling, most of the snow slides off, melts, or undergoes sublimation, the process by which it is transformed from ice crystals directly into vapor.



PHOTOGRAPH BY GETTY IMAGES

ILLUSTRATIONS BY VIC KULHIN (ROOF), MERCÉ IGLESÍAS (SNOWFLAKE ICON)

the fill valve. Most fill valves have a line or a tab marked CL, for "critical level." This should be at least 1 inch above the top of the toilet's overflow tube. If it isn't, back flow could contaminate the

house's potable water supply. So check the relative heights of your toilet's CL line and overflow tube—and if the former is below the latter, raise the valve, and thank your neighbor for the tip!

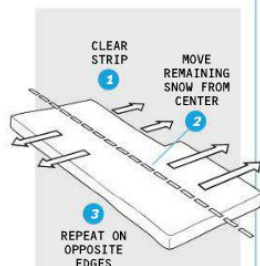
Good Wood? While pulling up carpet in our house, we found some nice, old oak flooring. It's somewhat like thin-plank flooring today. Should I consider refinishing it?



KNOW YOUR STUFF

SNOW BUSINESS

I HATE SHOVELING SNOW, BUT I DON'T HAVE A GARAGE OR SHED, SO IT'S NOT PRACTICAL FOR ME TO OWN A SNOW THROWER. WHAT'S THE MOST EFFICIENT WAY TO SHOVEL SNOW, AND WHICH SHOVEL IS THE BEST?

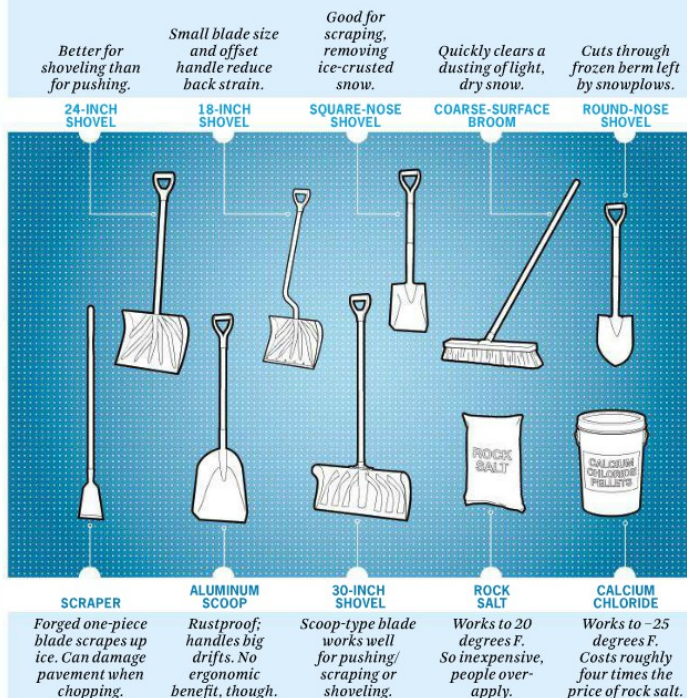


Easy Does It

The fundamental rules are to move snow once, and move it the shortest distance possible (for more on this, see "16 Cardinal Rules for Snow Shovelling" at popularmechanics.com). For a driveway, I clear a strip along one edge, then move snow from the center, across the cleared edge, and onto the grass (above). To avoid injury, I keep my back straight, knees bent, and feet shoulder-width apart. When I lift, sometimes I use the lower part of my thigh as a fulcrum point. I hold the shovel close to reduce the stress it exerts on me.

Choose the Right Tool

Snow shovels vary in size and shape, but all can carry 1 to 1.5 cubic feet of the white stuff. Snow weighs from 7 pounds per cubic foot to an astounding 30 pounds per cubic foot, so one shovelful weighs 7 pounds to 45 pounds. With this in mind, the best shovel is one that you can handle easily. "Try a shovel before you buy it," advises Joe Saffron, a marketing and product development manager at Ames True Temper, a manufacturer of shovels and gardening gear. "Wear the gloves you'll use outside and dry-shovel, making the same motions you would to clear snow." To that I would add: Consider buying more than one shovel. I have a large combination type for pushing and shoveling, and a smaller, lighter one for whittling down a big drift. I also use other tools (below).



ILLUSTRATIONS BY VIC KOLIMIN

Unless the wood has grown excessively thin from prior sanding and refinishing, you should go for it. You almost certainly have 5/16-inch oak flooring; you'll know for sure if it has square edges and is face-nailed into the subfloor. If you need a few pieces for repairs, you can still buy them, though you'll probably have to order them from a flooring supplier or on the Web.

Double Trouble We have an unfinished utility room, and I happened to be in there while the kitchen exhaust fan was running. It sounded as if the fan was making a noise in the masonry chimney, which runs up along one wall of the room. I investigated and found that the fan is discharging into the chimney—which also serves the furnace—via a sheet-metal pipe. This setup can't be good, right?

Right! Remove the sheet-metal duct and seal the hole in the chimney wall with fire-place mortar (www.rutland.com) and a chunk of firebrick. It's vital to create a perfect seal to prevent carbon monoxide (in furnace exhaust) from leaking into the house. You'll also have to find a new way to vent the kitchen range. Whoever jury-rigged the current setup did so against building code.

Bent Out of Shape

I mounted a closer for my storm door. It wasn't in place very long before the rod bent. Before I replace it, can you tell me what I did wrong? People often roll the dice and just replace the closer but not the mounting brackets that come with the closer. This is a classic mistake. It results in a bent closer rod or a closer that doesn't operate properly.

In other cases, people install the wrong closer. They install it properly, but it's the wrong size or type. When you buy the next closer, install the entire assembly, including the jamb brackets that come with it.

And here's some parting advice from Bob Lucchesi, one of the best

carpenters I know and a guy who installs and repairs dozens of closers every year, some of them very large and complex: "You've got to read the instructions," he says. "Do it before you install the hardware, not after, when something's wrong with it."

Riveting Question The handle came off my favorite kitchen knife because the rivets that hold both handle halves to the blade rotted through. The rivets look like they're stainless steel, so I was surprised that they would fail like that. Can the knife be repaired?

Sure. Buy knife-handle rivets (also called cutler rivets) from any number of sources online. Drill out the old rivets using a high-speed steel drill bit. To do this, clamp each half of the handle (known as a scale to a knife-maker) upside-down. Firmly mark the center of the rivet with a center punch, then drill out the rivet from the back. If there is anything left of the rivet, drive it out with the center punch. Install the new rivets by hammering the male half of the rivet into the female half. Then bring the rivet head smooth to the handle with some filing and sanding. If there's a small gap around the new rivet head, fill it in with appropriately colored two-part epoxy putty.

If I were you, I'd hand-wash that faithful kitchen knife to eliminate the heat, moisture, and aggressively alkaline detergent that combine in a dishwasher to cause the kind of damaging corrosion that you found.

PM

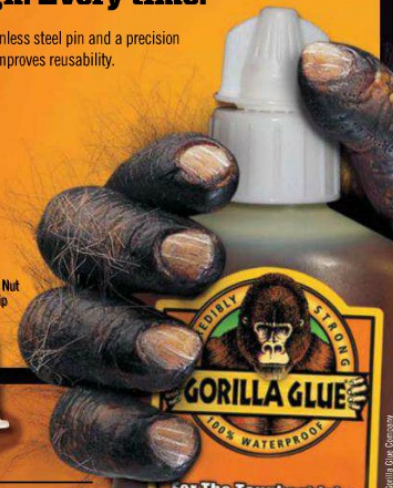
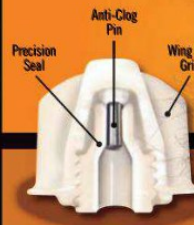
Got a home-maintenance or repair problem? Ask Roy about it. Send your questions to pmhomeclinic@hearth.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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Rec-Room Rack

BUILD A LIGHTED ACRYLIC RACK TO HANG TABLE TENNIS PADDLES, DARTS, AND BOXING GLOVES.

BY WILLIAM GURSTELLE

1 → ACQUIRE ACRYLIC

This functional light-up shelf for a basement rec room adds wall-mounted storage for such playtime miscellany as Ping-Pong paddles, balls, darts, and boxing gloves. Acrylic panels, lit by an LED strip, add style to seldom-used materials. To get started, obtain two pieces each of ½-inch- and ¾-inch-thick acrylic, cut by the supplier to about 6 x 12 inches. With a router or table saw, shave off ¼ to ½ inch (depending on the width of your LED lights) from the long side of one of the ¾-inch-thick pieces.

2 → MAKE A SANDWICH

Form a "sandwich" by inserting the cut ½-inch sheet between the two ¾-inch pieces. Square up the pieces so there is a ¼- to ½-inch-deep pocket on one side of the sandwich. Use acrylic plastic cement to bond the pieces together. Practice cementing acrylic using welding solvent and a slender applicator called a hypo.

3 → INSTALL LEDS

Drill holes for table tennis rackets, darts, and balls, as desired, on the sandwich piece. Drill two ¾-inch holes in the edge and insert a ¾-inch-diameter acrylic rod to make hanging pegs for gloves. Install an LED strip in the pocket of the acrylic sandwich. An adapter plugged into a wall outlet can power the LED.

4 → MOUNT THE RACK

Cement the sandwich to the other ¾-inch piece of acrylic. Reinforce the perpendicular joint with a ½-inch-square acrylic tube. Drill holes in the rear face, then secure the shelf and bracket to a wall using screws and wall anchors. Plug in the light—and enjoy!

½-INCH ACRYLIC

¾-INCH ACRYLIC

LED STRIP
REINFORCING TUBE
¾-INCH BRACKET

+ MORE TO DO IN FEBRUARY

Master the Toothpick

→ Georgia craftsman Mark Sillay and the Palmetto Woodturners hold a workshop in Columbia, S.C., Feb. 3 and 4, to share the "toothpick technique," a joinery method for pairing irregular objects.

Harvest Precipitation

→ Brent Clayton hosts a seminar on rainwater-harvesting systems at Texas A&M's El Paso extension on Feb. 28 and 29. Students get 100-gallon tanks, then "just go for it," Clayton says.

Organize the Garage

→ Assess the mess, says Indiana contractor and garage organization pro Dennis Ellis. Sort storage into short- and long-term items. On holiday décor: "Put that stuff up and out of the way," Ellis says.

Learn to Fix Planes

→ Bob Ripley of the American Bonanza Society holds a clinic in Lantana, Fla., Feb. 23 to 26, to teach Hawker Beechcraft owners the plane's anatomy. "We show how it works," Ripley says.

Stop an Avalanche

→ On Feb. 26 in Salt Lake City, Brett Kobernick of the Utah Avalanche Center instructs on how to avoid man-made avalanches. "It just looks like snow to the untrained eye," he says.

PHOTOGRAPH BY CREDIT LARGE NAME

PHOTOGRAPH BY PLAMEN PETKOV

ILLUSTRATION BY VIC KULHIN

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Your Car's Nervous System

A MAZE OF WIRES AND
COMPUTERS IS THE KEY TO
YOUR VEHICLE'S DEEPEST
SECRETS. BY BEN WOJTYLA

DIY

Auto

Saturday
Mechanic



• We get asked a lot of questions about the bits and pieces of cars that squeak and rattle and break—everything from why is my wheel going clickety-clack to how do I get rid of this rodent smell. But for some time now we've seen our inboxes stuffed with questions on the failings of electronic components. That says something about the technological progress of the automobile. Vehicles are increasingly behaving like computers with wheels, so it's time for a discussion of a little-known aspect of your car: its computer network. In

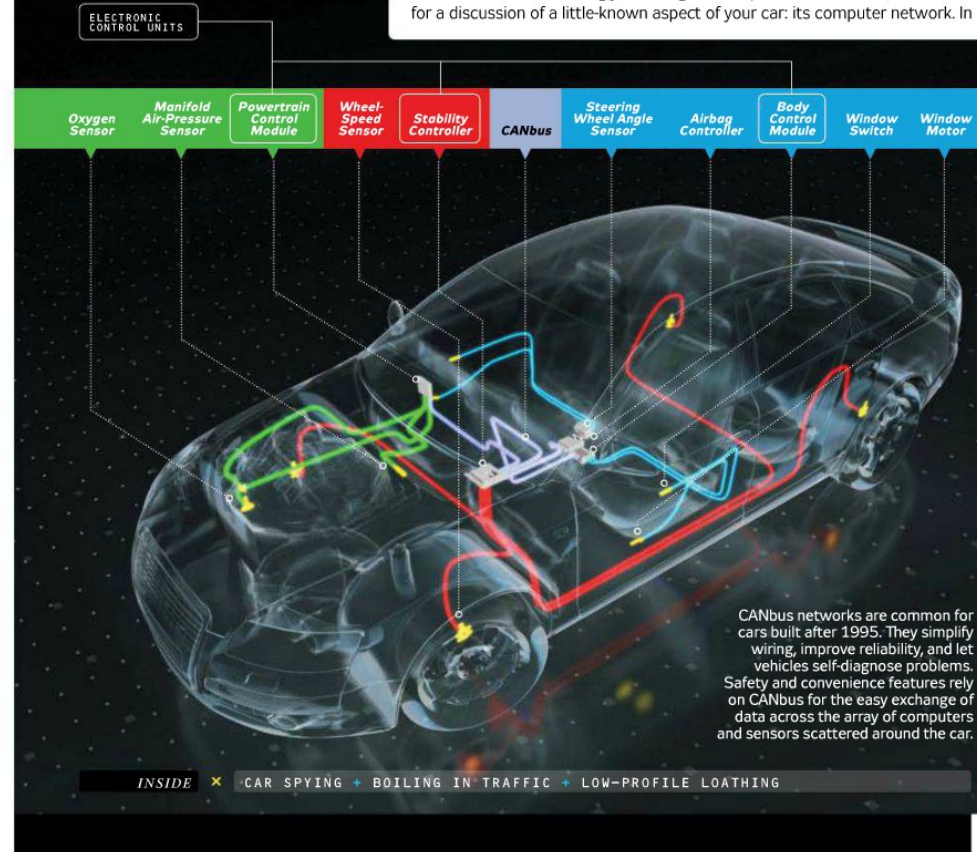


ILLUSTRATION BY VLADIMIR SHELEST

DIY Auto WHAT'S IN A NETWORK

the past we would have called it the electrical system, but its mission has evolved way beyond simply moving dumb electrons. Collectively, these electronics are known as the Controller Area Network, or CAN, but, to be specific, the system of wires and software protocols acting as the connective tissue between a vehicle's computers and sensors is known as CANbus. CAN allows cars to be smarter, cheaper, and capable of doing some slick stuff that wouldn't otherwise be possible.

An Infrastructure for Info

• We talked to Eric Paton, a technical specialist at Ford, about the intricacies of CAN. Paton says, "If there's one

thing drivers should know when getting into a car, it's that everything seems simple, but beneath the covers it's incredibly complex." The design of CAN is similar to that of a freeway system. Data move like vehicles from high-traffic highways to local roads via on and off ramps. Thousands of data points traverse this freeway at any time along any given stretch and can get off at any exit. Throughout the car are various computers called electronic control units, or ECUs—the traffic lights and intersections of our road-system analogy. Each ECU has several jobs: controlling the engine or transmission, rolling up windows, unlocking doors, and the like. These computers have sensors and switches wired in to detect variables such as temperature, pressure, voltage, acceleration at different angles, braking, yaw and roll of the vehicle, steering angle, and many other signals. When an ECU needs a signal from a sensor connected to an ECU elsewhere in the car, that's where CAN comes in.

Like a freeway, the CANbus network allows data from all the sensors and computers to circulate around the car at all times. Each computer transmits all its sensor and programming information constantly—as many as 2000 signals are floating around the network at any time, whether they're being requested or not. At the same time, each ECU "listens" to the network to pluck out pieces of information it may need to carry out its work. There is no central hub or routing system, just a continuous flow of information that's always available to the ECUs.

Take, for instance, power sliding doors, a common feature on modern minivans. These doors are operated by an ECU called the body control module. Sensors constantly report whether the door is open or closed, and when the driver pushes a button to close the door, the signal from that switch is broadcast across the network. When the ECU gets that signal, however, it doesn't simply close the door. First, it checks the data stream to make sure the car is in park and not moving. If all is well, it then gives a command to a power circuit that energizes the motors used to close the door. It goes even further, though—the ECU then monitors the voltage consumed by the motors. If it detects a voltage spike, which happens when a door is hindered by an errant handbag or a wayward body part, the ECU immediately reverses the direction of the door to prevent potential injury. In the old days, this would have been an engineering feat. Just electrically powering the doors would have required dedicated wires running between the shifter, the door switch, and the motor.

Before CAN was developed in the mid-'80s, every time an automaker

GEAR GUIDE DIGITAL DIAGNOSTICS

BY TAPPING INTO THE ON-BOARD DIAGNOSTIC (OBD-II) PORT UNDER THE DASH, A DO-IT-YOURSELF CAN UNLOCK THE MYSTERIES OF THE CAN SYSTEM. WITH THESE INEXPENSIVE DEVICES, YOU CAN MONITOR YOUR VEHICLE'S PERFORMANCE OR, IF YOU DARE, ENHANCE IT.

BEGINNER



GOPOINT'S BT1 MODULE plugs into the OBD-II port and wirelessly transmits to any Android or Apple iOS device. Then the fun starts. You can monitor transmission temperatures, manifold pressure, ignition-timing information, and a lot more. It also decodes the Check Engine light so you can either fix a simple problem—such as a loose gas cap—or determine if your car's ailment is serious enough to merit a visit to the mechanic. (\$119)

EXPERT



HYPERTECH'S MAX ENERGY POWER PROGRAMMER also plugs into the data port and lets you increase engine-rev limits, adjust transmission points, calibrate the speedometer, and, the company claims, remap fuel and spark delivery for more power. (\$340)

Our experience with these reprogrammers is mixed. Recalibrating the speedo is certainly handy, but unless your car is turbocharged, the power gains are modest at best, and fumbling with the car's programming will nix the warranty. So tread carefully.

added an electronic feature, like, say, heated seats, new, dedicated wires had to be added just to connect the heaters to a dash-mounted switch. Over the years, more features meant more wires, until there were literally miles of wire in wrist-thick vines snaking all over the car. With CAN, the seat heaters and the switch that powers them don't have to be directly wired together. They can simply "talk" over the existing CAN network—no special wires needed. What is needed, however, is some additional programming to get all the devices networked. It's a choice to shift toward programming complexity over physical complexity. CAN has made software development more challenging, but it has had many more positive effects: significant cost savings to the consumer, much lighter weight, reduced reliance on rubber and copper resources, and far better reliability with fewer wires to break over time. Those attributes may be important from a technical standpoint, but the most profound effect of this shift toward programming is on vehicle diagnostics and software updates.

Car, Heal Thyself

• The shrinking of the car's wiring harness and other benefits were not the main impetus for the creation of CAN. As pollution requirements matured in the late 1970s, the National Highway Traffic Safety Administration and the California Air Resources Board demanded ways to monitor the effectiveness of vehicle-emissions-control systems. The result of that directive was the standardized On-Board Diagnostics protocol (now in its second generation, known as OBD-II) that required a CAN network to efficiently connect to all the engine sensors for a self-diagnosis. With this interconnection, a designated ECU can watch the network for problem reports broadcast to the network as OBD-II codes. If an ECU detects a problem, it broadcasts it as an alphanumeric code and the Check Engine light is turned on. Modern cars

WHAT'S NEXT

WIRED LIKE THE WEB

Your car's electronics network may be sophisticated, but as the amount of data it handles increases over time, it will have to be upgraded. Most likely, cars will adopt an Ethernet-based system such as VEEDIMS, the one in the high-tech Iconic AC Roadster (below). VEEDIMS assigns each vehicle component an IP address so that centralized and remote computers can pass around huge amounts of information. Attach a cellular connection and data can be beamed to the cloud for analysis. Dealer visits for software upgrades could be replaced by a download. What's holding all this back? Legacy costs. It would take billions to re-create the software. But car Ethernet is coming—someday.

• VEEDIMS SYSTEM



• ICONIC AC ROADSTER



carry out these self-checks any time the car is running. Anyone with a handheld code reader (see "Digital Diagnostics," page 90) can plug into the standard 16-pin data port in the driver footwell and retrieve fault codes. An Internet search will usually explain the fault or at least give a hint at the problem.

That same data port also comes in handy if a manufacturer uncovers a computer glitch or wants to modify how the car operates. For example, a carmaker may develop an algorithm for smoother transmission shifts. Installing it in any customer car is as simple as a dealer technician plugging his computer into the data port and uploading the new software. Before CAN, this would've meant physically replacing an ECU.

Peeking Behind the Digital Curtain

• The heavy tinkers out there know all about the ability to reprogram, or hack, a car. Manufacturers frown on the practice, of course—it will void your warranty—but not everyone can resist the urge to reverse-engineer code and make a few changes. Unless you're sporting a computer-engineering degree, hacking into the system directly is inadvisable (if you accidentally grenade your engine, you'll be left with a car-shaped driveway ornament), although some aftermarket products make interacting with your car's network quite rewarding, especially if you're a speed freak. Mechanics in hot-rod shops, who modify engines for more horsepower, have been successfully reprogramming cars for at least a decade. But, remember, they're professionals.

Car Clinic

by Ben Wojdyla

What Your Car Knows

This airbag control module (ACM) from a 2006 Ford Fusion houses a component called the event data recorder (EDR), which monitors driving conditions surrounding airbag deployment and logs information about the last few seconds before a crash. Accident investigators, such as Crash Data Services of Algonquin, Ill., which supplied us with this unit, can then extract the following information:



Is My Car Spying on Me?

As cars become more computerized and more connected, how much data is my vehicle collecting about my driving, and who has access to that information?

A A modern car knows where you are, is constantly tracking your driving habits, and may even be able to call for help if you crash. It's revolutionary, potentially lifesaving—and just a bit creepy. Most of a vehicle's computers are scattered around the car and carry out mundane tasks—operating the engine and transmission, windows, seats, and the radio—and these computers don't have data-storage capability (see "Your Car's Nervous System," page 89, for a detailed tour).

However, the airbag-deployment controller is a bit different. It contains a component called the event data recorder (EDR), which monitors the vehicle's network of sensors for signs of a crash and stores a few seconds of the data stream, dumping and refreshing the information constantly. The type of information collected in the EDR varies among manufacturers, but it generally includes throttle and brake-pedal position, steering angle, yaw rate (the vehicle's rotational velocity), speed, and impact-sensor data. This information is saved permanently following an airbag deployment

and can be accessed through the OBD-II port by a technician using specialized equipment. EDRs have been used since the 1990s and have recently been standardized by the National Highway Traffic Safety Administration (NHTSA)—EDRs will be required equipment on all cars beginning in 2013, with the aim of making their data easier to obtain for crash investigations. Lawyers have used this data in court cases to demonstrate driver behavior during an accident. In a Pennsylvania lawsuit related to the Toyota Prius unintended-acceleration controversy of 2009 and 2010, a team of Toyota engineers and NHTSA officials accessed the EDR of the car in question, showing that the driver was depressing the gas pedal instead of the brake, as he'd claimed.

Most navigation systems are separate from a car's computers and cannot track your location. Nav systems rely on the Global Positioning System, which is a one-way data stream to the car. Your car may know where it is, but nobody can track it via the GPS link, and no location data is stored in the EDR.

But everything changes when you add a cellular connection. Cars equipped with telematics systems such as OnStar or Hyundai Blue Link have two-way links to service providers that relay GPS data. The operators of these services do, indeed, have the ability to see where you are, how fast you're going, and what state your car is in mechanically. They can also track and remotely disable a stolen vehicle. The Nissan Leaf uses a similar two-way connection to regularly send data on usage and location to Nissan, which the company uses for future electric vehicle development. But these services aren't supposed to work without driver permission. The car can initiate a call in an emergency situation, such as when an airbag is deployed, but otherwise the driver must authorize an external connection to the vehicle.

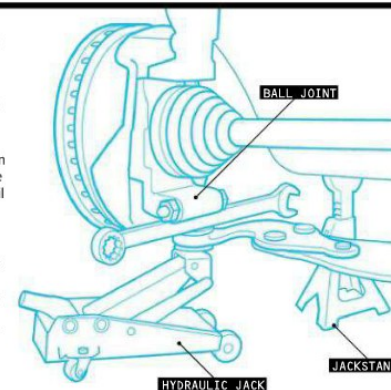
Companies have been caught snooping, though. OnStar found itself in the midst of a public uproar last Sep-



QUICK FIXES

THE EASY WAY TO LOOSEN A BALL JOINT

→ Freeing front suspension ball joints can be frustrating. Rather than wrestle with pry bars and special tools, jack up the corner of the car and lower it safely onto a jackstand placed under the frame. Reposition the hydraulic jack under the suspension and raise it until the car nearly lifts off the stand. Take your largest wrench and wedge it between the bottom of the steering knuckle and the suspension arm. Lower the jack to force the suspension geometry to press the joint loose. If this doesn't work, the wrench is great to hammer away on.



tember when it quietly changed contract terminology and started tracking customers with the intent of selling information about their driving habits. OnStar reversed the policy under pressure from consumers and Congress. Recently, insurance companies Progressive and State Farm have begun testing tracking systems, which policyholders plug into their OBD-II port. The systems record data on driving habits, and in exchange customers can potentially get lower insurance premiums, but any data collected belongs to the insurer (including any crash data).

What can you do about it? If you're a new-car buyer, not much. But pay close attention to the language of the user agreement for any telematics service—if you don't like what you read, opt out of the service. With EDRs, it's enough simply to know your rights. The law is still playing catch-up to the technology, but at this point you do not have to surrender the EDR data to the police without probable cause, a warrant, or a subpoena.

Boiling Point 🚗 I have a 2000 Chevy Malibu with a 3.1-liter V-6, and I notice that when I'm stuck in traffic, it starts to overheat. Turning on the air conditioning drops the temperature back down. The temperature is fine going down the road at 60 mph or so. Any ideas?

There could be several issues here. The first thing to do is check the coolant when the engine is cold. Ensure that it's clean and filled to the correct level. Your GM (should have orange coolant; if it's any other color, flush and replace it (other manufacturers use green). If you have to refill the coolant reservoir often, it may indicate big trouble somewhere in the engine, perhaps a leaky cylinder-head gasket. If the coolant has never been replaced—the useful life of a coolant is about 10 years, regardless of mileage—you should probably do that too. Next, check your radiator cap and make sure it's on tight and in good condition. If the seals in the underside of the cap look brittle and cracked, they've probably failed. The coolant system depends on everything remaining tightly sealed, otherwise it can't pressurize and the coolant will boil, causing a spike in temperature in some very critical places

PHOTOGRAPH BY GREGG DELMAN

ILLUSTRATIONS BY TAMER KOSER

ILLUSTRATION BY VIC KULIHIN

DIY Auto CAR CLINIC Q+A

like the cylinder head. If the problem persists, it's possible your water pump's gone bad and can't circulate enough coolant for the engine, driving temperatures up while you're sitting at idle.

Rough Rider Nearly every new car seems to offer low-profile tires. I like the look, but I've heard folks complain about jarring rides, frequent blowouts, rim damage, and

greater wear at lower mileage. Should I avoid them?

Low-profile tires do seem to be popping up on a lot more cars these days, but they're being offered for several reasons. Bigger wheels and skinnier sidewalls in a normal-size wheel well mean manufacturers can make room inside the wheel for larger brakes. Thin sidewalls are also stiffer and deliver better cornering and road feel. Let's not avoid the obvious though—low-profile tires just look cooler than regular tires.

When we say low-profile, we're talking about the size of the edge of the tire. Read the numbers molded into the sidewall; the second number printed in the series is the aspect ratio, indicating sidewall thickness as a percentage of tread width. For example, a P225/45R15 tire has a 15-inch wheel size with 225 mm of tread width, and the sidewall is 45 percent of tread width, or 101 mm. The higher the aspect ratio, the thicker the sidewall and the comfier the ride; lower aspect ratios lead to thinner sidewalls and a stiffer ride. There are drawbacks to this kind of rubber. Tires are a part of your car's suspension—the sidewalls absorb some of the most vicious road imperfections. Unless the suspension has been designed to accommodate the stiffer sidewalls, it can mean a rougher ride. Blowouts (a hole in the tire caused by road debris) shouldn't be more frequent than with normal tires since the tread and ply construction aren't much different. Rapid deflation is something to be concerned about; hitting a pothole with thin sidewalls can damage the wheel. Tiremakers constantly improve designs with more robust materials and construction, so newer tires aren't damaged as often as old low-profile tires.

If you're buying a new car for comfort, order smaller wheels fitted with larger-sidewall tires—they'll offer a softer ride. Less aggressive shocks may help a bit but at the cost of handling. Beyond this, you're looking at changes to suspension hardware, which isn't for the faint of heart. You'll have a tough time finding parts anyway, as the aftermarket usually aims to make cars more rigid rather than pillow soft. **PM**

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Antarctica

(CONTINUED FROM PAGE 69)

we walk right by them. Palmer's Glacier Search and Rescue (GSAR) team has gallantly offered to drop me into Marr's yawning maw. And then, I hope, pull me back out again.

To get to the glacier, we first have to walk to it. This wasn't always the case. In 1967 the base of the glacier came right to the station. Since then it has pulled back 1600 feet. In fact, 87 percent of all glaciers on the West Antarctic Peninsula are receding. At the end of November, I lost shoe crampons in the glacier as my feet sank through a thick layer of snow. Now, in late December, it's like hiking over the crust of freezer-burned ice cream.

When we reach a manhole-size opening, Paul Queiro sets up a belay system, twisting three 9-inch screws into the ice. Palmer has so few staff that they all take on multiple roles: Queiro is an IT specialist, but he's also an EMT on the trauma team and leads GSAR. He talks as enthusiastically and knowledgeably about the station's bandwidth as he does about intubating patients and climbing Kilimanjaro.

At Palmer, this isn't particularly unique. "You learn immediately that it doesn't matter what someone's job is—they're brilliant and they're capable," Queiro says. "You know you better not prejudge because you'll find out that wastie"—waste management specialist—"has two degrees and can beat the pants off you in a debate."

Ted McKinley, the station's carpenter, descends into the crevasse first, the very top of his wool hat disappearing into the ice. His voice is tiny when we next hear it: "Okay, can't do plan A. There's nothing to anchor to on my left. Going to my right." He finds a good hold and gives the all-clear.

Now it's my turn. Nestled firmly in my harness, I'm lowered down the chimney-like hole until I find footing on an ice bridge. The crevasse yawns, bottomless, below me and as far as I can see in either direction—intensely blue and pocked with cottony snow and sheets of icicles. It's breathtaking.

As I settle into an alcove next to McKinley, my feet hanging over the abyss, I think about something Tracey Baldwin, Palmer's science support manager, told me back at the station. Marr Glacier used to calve into the ocean with a splash, sending giant waves across Arthur Harbour. Now, as she sits in her office, she can still hear the glacier calving, only it sounds like thunder—because it's receded so far it's calving on land.

AS A VEGETARIAN, I ignore the chicken bucket and instead scrape my food scraps directly into the baby grinder. The station garbage disposal, presumably named for its size, sends them to a masticator where they're ground up, mixed with wastewater and copious salt water, and pumped into the harbor for the tide to sweep out. The rest of Palmer's trash has to follow the "leave no trace" principle of the Antarctic Treaty: Pack it in, pack it out. There are no landfills in Antarctica.

Jed Miller is Palmer's wastie. His domain comprises a series of rusting metal shipping containers marked with hazard symbols and lined with steel drums. Solid waste—including poultry, lest it introduce an avian disease to the ecosystem—is shipped back to Chile. Hazardous waste, such as lab chemicals, goes all the way to Washington state. "My boss, the head of waste management, says that our department is not supporting science," Miller says. "We're here to uphold the Antarctic Treaty—that's what we care about. We care about making this place clean and pristine."

Miller started working in Antarctica 12 years ago and has cycled through all three U.S. stations—winter-overing twice. When I ask if he'll be back next year, he says his last season was supposed to be two years ago. Glass tells me that's not unusual. "I could potentially never be done with Antarctica," she says. "Part of me sometimes thinks I want a regular life, but then I talk to folks back home who have that 9-to-5, the commute, and all of the above, and I realize if I were to do that I'd be wanting to come back here pretty quick."

"ATTENTION, PALMER STATION. There's a leopard seal attacking a penguin in Arthur Harbour." As the alert crackles over the PA system, everyone in the bar grabs a beer and rushes onto the balcony to watch.

SAVED! I think. Glancing over the edge of the gravel dock, I can see the water is filled with sharp chunks of brash ice. Jumping into that would be like leaping into a half-blended margarita, blades and all. It would be crazy.

Only, by lunchtime, the brash has all blown back out. I'm told to go put on my bathing suit.

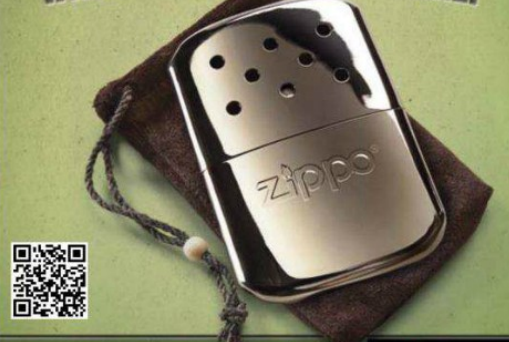
The polar plunge is a ritual at Palmer. Mostly, it's done as a farewell to the departing *Gould*—but people also plunge for more spontaneous reasons, such as the initiation of visiting journalists. As polar fleeces and wool hats fall to the ground around me, their owners soaring off the dock in alternating swan dives and cannonballs, I'm torn between getting it over with and postponing the inevitable: Then, with a final glance at the nearby outflow pipe, I decide to go for it.

The hollow rubber fender is firm under my bare toes as I climb up and bounce a few times experimentally. It's freezing in the air, too, so I assess the water, aim for an opening between the few remaining pieces of ice, and leap. For a split second, time stops, suspended—then splash. *It's cold!* I swim faster than I ever have for the rusted ladder leading back up to the dock, then run 80 yards to the station hot tub. It's already crowded.

I slip into the water between Palmer's logistics coordinator and one of the Birders. The tank, like the Southern Ocean we just jumped into, contains a cross section of life along the West Antarctic Peninsula—representatives of the entire station ecosystem. Steam rises around us. My short, wet hair, meanwhile, freezes into crunchy icicles. The low rumble of elephant seals challenging each other floats across the harbor. Beyond my shoulder, Marr Glacier towers over the still blue water, then calves, thundering. There is no splash. **PM**

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TRACKING DISEASE THROUGH TECHNOLOGY

SENSOR NOTES → Roughly five of every 100 patients will acquire a bacterial infection in a hospital. To help decrease those odds, Polgreen designed sensors, or motes, to find what he calls a hospital's Kevin Bacons—people who are especially well-connected and thus more likely to spread contagion. Carried by healthcare staff, the motes report time-stamped location data to a base station every few seconds. Polgreen uses that data to build models showing how healthcare workers might spread infectious diseases.

SOCIAL MEDIA → After the H1N1 outbreak in 2009, Polgreen's team used data from the Centers for Disease Control to develop algorithms that mine Twitter, extracting keywords to determine which tweets were associated with more disease activity. The algorithms predicted flu levels geographically and in real time with an average error of only 0.28 percent from the CDC reported results, which are released one to two weeks after the fact. These algorithms may one day serve as an early warning system for distributing vaccines and mobilizing healthcare workers.

SMARTPHONE APPS → Less than 50 percent of healthcare workers practice adequate hand-washing hygiene. Hospitals typically hire independent monitors to shadow employees and track compliance on paper, but Polgreen and his colleagues saw another opportunity to use technology to solve a problem. They created iScrub, an app that human monitors use to input data. It minimizes entry errors, standardizes recording, and provides real-time feedback.

x **Most outbreaks begin with one unlucky person, who's typically not easy to find.** At the start of the 2002 SARS epidemic, epidemiologists relied on hospital logs and patients' memories to identify the first victim and trace the path of exposure. But Philip Polgreen, who worked in a virology lab at the University of Iowa at the time, believed that technology could more accurately track how diseases spread. After becoming assistant professor of medicine and epidemiology at Iowa's Carver College of Medicine in 2006, he co-founded the Computational Epidemiology Group, an interdisciplinary research team. They use mathematical and scientific tools to collect data and build models about contagion. "It's an incubator for ideas," he says. "There's always a new infection and a new way to track transmission." —EMILY HAILE

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